PATENT SPECIFICATION

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DRAWINGS ATTACHED.

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COMPLETE SPECIFICATION.

Improvements in and relating to the Formation of Plastic Articles.

We, OWENS - ILLINOIS INC., formerly Owens-Illinois Glass Company, a Corporation of Ohio, United States of America, of Toledo, Ohio, United States of America, (Assignee of THOMAS ROBERT SANTELLI and LAWRENCE DUANE NINNEMAN), do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a method and apparatus for forming blown plastic articles.

In the blow moulding of plastic articles, such as containers or the like, the present commercial practice basically involves the extrusion of a tubular blank of heat-softened plastic material, closing a sectional blow mould on the tube to pinch the tube shut at one end, and finally injecting air under pressure through the other, still open end of the tube to inflate the pinched tube to the configuration of the blow mould. Several variants of this process are utilized, such as extruding the tube as a freely pendant length and blowing the entire container in the blow mould; closing "clam-shell" moulds mounted in series on a turntable on successive portions of a horizontally extruded tube and injecting air through a needle puncturing the tube length interiorly of the mould; or injecting a neck portion of the container followed by the extrusion of a tube integral with the neck, pinching the tube shut in a blow mould enclosing only the tube, and then blowing the tube by air introduced through the earlier injected neck. In any event, closure of the tube by the blow mold necessarily produces a waste or "tail" portion which must be removed subsequently from the blown article and, where the neck or "finish" of the container is also blown, "neck flash" or neck-joined waste portions are also produced for necessary later removal.

To eliminate such waste portions, the utilization of injection molded preforms or blanks has been proposed. Such processes generally require reheating of the injection molded blanks before blowing, thus substantially slowing the production cycle. Even more seriously, the formation of the blank by conventional injection molding procedures produces a blank and a finished article of undesirable character, due to the introduction of plastic material into the blank mold through an injection passage and a passage-to-mold orifice of greatly reduced cross-sectional dimension relative to the other dimensions of the mold. The utilization of such small openings is necessary in order to rupture the injection molded blank from the source of plasticized material, usually from a sprue or runner joined to the injection mold cavity by the reduced orifice. The thermal variations encountered by the more rapid solidification, in fact "super-chilling", of the material at the orifice induce into the injection molded preform built-in stress-concentration points, resulting in stress cracking, warpage and structural weaknesses concentrated at the sprue-to-mold juncture area. Thus, there is necessarily present in any blank produced by conventional injection molding procedures a weakened section which may rupture during subsequent blowing of the blank or which, even if not ruptured, results in a weakened portion of the final blown article.

The present invention now proposes the formation of a blown article by a process eliminating the inevitable waste portions of

the various tube-blowing processes and also eliminating the inherent weakening of the blank and/or the article. Thus, an improved article free of waste and free of structural weaknesses, and possessing the full isotropic properties of the plastic material is obtained for the first time from an injection molded preform.

More particularly, the present invention proposes the formation of a waste-free injection molded and subsequently blown blank by the formation of the blank in an injection mold wherein the material to be injection molded is introduced into the mold cavity through a passage corresponding in size substantially to one end, usually the closed bottom end, of the injection molded blank. By thus eliminating a subsequently fractured connection through a substantially reduced orifice to the source of plastic material, the present invention eliminates the inevitable thermally weakened portion of previously injection molded blanks. By utilizing the blow head as a portion of the injection molding apparatus, it is possible to immediately blow the injection molded blank without the necessity of reheating. Alternatively, by the immediate transfer of the injection molded blank to a blow molding station, a separate blow head may be inserted into the blank and utilized for blowing the blank to its final configuration without reheating.

The resultant article possesses the full isotropic properties of the plastic material and is free of those thermal instabilities and inherent stress concentration points encountered in the use of previously proposed processes utilizing reduced injection orifices and forming subsequently ruptured joining portions of reduced cross-sectional dimension relative to the blank and/or the final article.

According to the present invention there is provided a method of forming a hollow plastic article by introducing internal fluid pressure into a hollow plastic blank, which is produced by pressure moulding plasticized material within an injection mould, and expanding the blank into the form of the finished article, characterized in that one end of the injection mould, across which is formed one wall of the finished blank, is open and the perimeter of this open mould end extends away from the mould cavity as a passage, and said pressure moulding comprises the steps of depositing a measured charge of plasticized material in said passage, transferring the deposited charge along the passage into the injection mould cavity, and concurrently closing the open mould end and applying pressure to the plasticized charge within the closed mould cavity by advancing a piston along the passage as far as the volume of plasticized material in the mould cavity will permit.

The invention will be further described by way of example with reference to the accompanying drawings in which:—

Fig. 1 is a vertical sectional view of an injection molding apparatus capable of carrying out the initial injection molding step of the process of the present invention;

Fig. 2 is a view similar to Fig. 1 illustrating the apparatus during the injection molding of the blank;

Fig. 3 is a vertical sectional view illustrating the apparatus positioned to carry out the blowing of the blank to the configuration of the final article;

Fig. 4 is a horizontal sectional view illustrating the manner in which plastic material is supplied to the injection molding cavity;

Fig. 5 is a vertical sectional view similar to Fig. 2 and illustrating a different form of apparatus for carrying out the process;

Fig. 6 is a view of the apparatus of Fig. 5 illustrating the removal of the preform from the injection molding apparatus;

Fig. 7 illustrates the apparatus of Figs. 5 and 6 at the conclusion of the blowing step;

Figs. 8, 9 and 10 are similar to Figs. 5, 6 and 7, respectively, and illustrate a further modified apparatus;

Figs. 11, 12 and 13 are similar to Figs. 5, 6 and 7 and illustrate yet another modified form of apparatus wherein the blowing step is carried out by a blow head separate from the injection molding apparatus;

Figs. 14, 15 and 16 are similar to Figs. 5, 6 and 7 and illustrate still another modified form of apparatus for carrying out the process of the present invention;

Figs. 17, 18, 19, 20 and 21 are similar to Figs. 5, 6 and 7 and illustrate a further modified form of apparatus for carrying out the process of the present invention;

Fig. 22 is an elevational perspective view of a machine particularly adapted for carrying out the process illustrated in Figs. 17—21;

Fig. 23 is a sectional view illustrating the accumulator and accumulator ram structure for storing and dispensing plasticized material;

Fig. 24 is a fragmentary elevational view taken along the plane 24—24 of Fig. 23;

Fig. 25 is an enlarged sectional view taken along the plane 25—25 of Fig. 23;

Figs. 26—28 are enlarged fragmentary sectional views similar to part of Fig. 23 illustrating the operation of the accumulator in storing and dispensing plasticized material;

Fig. 29 is a vertical sectional view illustrating the injection piston and piston actuating components taken along the plane 29—29 of Fig. 23;

Figs. 30 and 31 schematically represent the overall electric control circuit for the apparatus;

Fig. 32 is a sectional view taken along the plane 32—32 of Fig. 29;

Fig. 33 is an elevational view, with parts broken away and in section showing the cross head arrangement and the parison plunger;

Fig. 34 is an enlarged fragmentary view illustrating a portion of the cross head arrangement of Fig. 33;

Fig. 35 is an elevational view of the cross head arrangement taken along the plane 35—35 of Fig. 33;

Fig. 36 is a perspective elevational view illustrating the parison molds and the manner of their actuation;

Fig. 37 is a horizontal sectional view taken through the parison mold and actuating mechanism of Fig. 36;

Fig. 38 is a side elevational view of the blow molds and blow mold actuating mechanism;

Figs. 39 and 40 are schematic representations of the hydraulic control circuit for the entire machine; and

Fig. 41 is a schematic representation of the pneumatic control circuit.

As shown in the drawings:

THE EMBODIMENT OF FIGURES 1 TO 4

In Figs. 1 to 4, there is shown one form of apparatus for carrying out the method of the present invention and including an injection molding apparatus indicated generally at 20. The apparatus illustrated in Figs. 1 to 16 of the drawings are shown as particularly adapted to the manufacture of bottles or containers having neck or "finish" portions which are exteriorly peripherally threaded. It will be appreciated that the apparatus and methods herein disclosed are well adapted to the manufacture of other articles and that the specific showing of containers is merely exemplary.

More specifically, the injection molding apparatus 20 includes a centrally located body mold 21 having a central cylindrical mold cavity 22. The mold 21 is preferably oriented so that the axis of the cylindrical cavity 22 extends vertically, although, if desired, the axis of the cavity may be oriented horizontally. The central blank mold 21 is provided with an upper recess 23 concentric with the axial bore 22 and snugly receiving therein a lower embossed portion 24 of an upper neck or "finish" mold 25 comprising transversely separable mold segments 26. The utilization of such mold segments and various actuating means for separating the same transversely are well known in the art and need not be described in detail herein.

The mold segments 26 each carry internal blocks 27 movable transversely therewith and defining at their lower ends the upper extremities of a generally cylindrical neck mold cavity 28 cooperably defined by semi-cylindrical recesses in the abutting faces of the mold segments. When closed, the segments 26 are aligned with the body mold 21, so that the bore 22 cooperates with the neck mold cavity 28 to define the complete exterior periphery of the desired preform.

The interior periphery of the mold cavity is defined by a tube 30 projecting axially into the neck mold cavity 28 and the bore 22 with the cylindrical periphery 31 thereof being spaced peripherally from the cavity 28 and the bore 22 to define a complete mold cavity, as indicated generally by reference numeral 33. The lower axial extremity of the tube 30 is internally chamfered, as at 34, to define a valve seat against which is seated a blow valve element, indicated generally at 35 and having a lower enlarged head 36, the frusto-conical exterior periphery of which cooperates with the chamfered valve seat 34 to control the flow of air, in a manner and for a purpose to be hereinafter more fully described, through an annular flow passage 37 defined between the valve element 35 and the inner periphery 38 of the tube 30.

Located in axial alignment with the mold cavity 33 and underlying the mold block 21 is a material supply block, indicated generally at 40, and having an axial passage 41 therein axially aligned with the mold cavity 33. The supply block passage 41 carries a liner 42 which is annular in cross-sectional configuration having an internal bore 43 defined by a tubular body 44 and an upper radially enlarged head 45 covering the joint between the supply block 40 and the mold block 21. More particularly, the radially enlarged head 45 is snugly seated within a recess 46 in the lower portion of the mold block 21. In addition to bridging the gap between the mold block 21 and the supply block 40, the enlarged head 45 defines the extreme lower portion of the mold cavity 33 by the provision of curved inner edge 47, thereby preventing the necessity of milling or otherwise forming this smoothly contoured edge in a relatively inaccessible portion of the mold block 21.

Reciprocable within the supply block 40 is a vertically movable injection piston 50. The piston 50, of course, fits snugly within the supply block bore 43 and has an upper, planar, circular face 51 formed at the end of a piston head 52 joined to and movable with an actuating rod 53 movable by a suitable source of power, such as a fluid actuated cylinder (not shown).

Plastic material is supplied to the supply block bore 43 through a transverse supply passage 55 within which a reciprocable supply piston 63 operates. As best illustrated in Fig. 4 of the drawings, this transverse

supply passage 55 communicates through a connecting port 57 with a transverse supply passage 58 adapted to receive plasticized material 60 from a suitable source, such as a screw-type plasticizer indicated generally at 61. Preferably, the supply passage 58 is branched, as through a sleeve 62, to terminate in two ports 57 on opposite sides of the supply passage 55. Material enters the supply passage 55 through the ports 57 and is displaced into the bore 43 by means of the piston 63 which is actuated by a fluid pressure cylinder 64. The leading face 65 of the piston 63 is arcuate to blend smoothly with the contour of the bore 43.

After the plasticized material 60 has been supplied to the bore 43 by operation of the supply piston 63, the injection piston 50 is advanced through the supply chamber 43, picking up the plastic material from the supply piston 56 and displacing the material upwardly into the injection mold cavity 33.

The injection molding step is well illustrated in Fig. 2 of the drawings from which it will be seen that substantially one complete dimension of the injection mold space is defined by the face 51 of the piston 50 and the material within the injection mold space is not connected to any source of plasticized material or to any pressure source by any restricted orifice or the like.

Appropriate thermal control elements, such as coolant circulation passages or even electric resistance heaters, may be provided in the mold block 21, the neck mold 26, the tube 30, and/or the piston 50 to provide for the thermal control of the plasticized material within the mold space 33 without undue or harmful differences in cooling rate between various portions of the injection molded article.

Thus, the injection molded article is formed without any thermal or structural weaknesses inherent in cooling at largely different rates or those weaknesses effected by the juncture of the mold with a pressure or plastic source through a restricted orifice, as in conventional high pressure injection molding procedures. Further, the utilization of the multi-part mold including the insert tube 30, the pison 50, the sleeve 42, the body mold 21 and the neck mold 25 accommodates the formation of injection molded preforms or blanks of complicated shape without interfering with the molding of such preforms at relatively low pressures and also accommodates the thermal control of the plasticized material forming the preform without substantial thermal differentials thereacross.

Following the formation of the preform as illustrated in Fig. 2 of the drawings, the injection molded preform is removed from the body mold 21, such removal being effected without removal of the blow tube 30 and without removal of the composite neck mold 25. Such removal of the injection molded preform may be accomplished by axially upwardly withdrawing the assembly of the preform, neck mold and blow tube. Alternatively, a segmental body mold may be provided, the body mold segments then being laterally separable to more readily accommodate removal of the injection molded preform.

In any event, the preform is removed, preferably vertically, from the body mold 21 and the body portion of the mold is enclosed in a pair of separable blow mold segments 70, these blow mold segments having abutting vertical faces 71 and interior cavity- defining surfaces 72 which cooperatively define the final configuration of the blown portion of the article.

In the manufacture of containers or similar articles wherein an injection molded portion of the final article is preferred, which portion is not blown to its final shape, the blow mold segments 70 are closed upon only that portion of the preform which is to be blown to its final configuration, the remainder of the article preferably being enclosed within the equivalent part of the injection mold until after the blowing step has been accomplished. Further, it will be noted that the height of the injection molded preform is less than the height of the final article and less than the height of the blow mold cavity 72. Thus, closure of the blow mold segments 70 onto the preform does not pinch the preform and does not form any waste portion which must be subsequently severed therefrom.

In the utilization of the apparatus of Fig. 3, the valve rod 35 is actuated vertically downwardly to open the valve port defined by the chamfered surfaces 34 and to accommodate the passage of blow air through the annular space 37 defined between the blow tube 30 and the valve rod 35 and hence between the rod head 36 and the chamfered valve seat surfaces 34. Air so introduced into the interior of the preform will readily inflate the preform against the mold cavity surfaces 72 so that the final blown portions of the article are formed. Due to the absence of structural or thermal weaknesses in the preform, there is no danger of the preform "blowing-out" during introduction of air at blowing pressures of one hundred pounds per square inch or greater.

Following the blowing of the final article, the separable blow molds are opened. The separable blow mold segments 70 are laterally separated, and the segments 26 of the neck mold 25 are also laterally separated, so as to accommodate removal of the final blown article from the composite mold. Following such removal, the neck mold 25 is moved downwardly into engagement with

the body mold 21 for the next injection molding step. The hereinbefore described cycle is then repeated.

THE EMBODIMENT of FIGURES 5 TO 7

In that modified form of the apparatus illustrated in Figs. 5 to 7 of the drawings, the overall process is the equivalent of that carried out by the apparatus of Figs. 1 to 4, but certain variations in the apparatus are provided. For example, the intermediate body mold 21 is eliminated and a single combined supply block and body mold block 80 is utilized.

This combined block 80 is provided with a vertical bore 81 into which is fitted a concentric liner or sleeve 82, the bore 83 of which communicates with the lateral plastic supply passage 55 (earlier described) through a transverse sleeve port 84. The sleeve is provided with an integral, radially outwardly extending flange 85 provided with an upper recess 86 into which the neck mold 25 snugly fits, as heretofore described in connection with Figs. 1 to 4. The piston 50 fits snugly in the bore 83 for displacement vertically therein to provide the injection molding pressure source.

The operation of the embodiment of Figs. 5 to 7 is substantially the same as that disclosed in conjunction with Figs. 1 to 4 in that the injection molding step takes place in the composite mold defined by the neck mold 25, the blow tube 30, the sleeve bore 83 and the piston 50. All of the advantages of injection molding without substantial thermal differentials and without feeding material through a restricted orifice are obtained.

Following the injection molding of the blank or preform, the neck mold 25 is elevated concurrently with upward displacement of the piston 50 as illustrated in Fig. 6, so that the piston aids in stripping the injection molded preform from the sleeve bore 83. Following expression of the preform from the sleeve 82, the lower portions of the preform are enclosed in blow mold segments 70 and blowing is accomplished through the blow tube 30, all substantially as heretofore described.

THE EMBODIMENT OF FIGURES 8 TO 10

In that embodiment of the invention illustrated in Figs. 8 to 10, the neck mold 25 has been modified somewhat in that the neck mold segments 26 surround semi-cylindrical upper plug segments 90 movable with the mold segments 26, respectively, and having under-surfaces 92 defining the upper extremity of the injection mold cavity 33, the plug segments also including semi-cylindrical outwardly directed flanges 93 overlying the neck mold segments 26.

The main or body injection mold 21 is also substantially the same as that described in conjunction with Figs. 1 to 4, with the exception that the mold cavity 33 is tapered downwardly and inwardly to form a resultant frusto-conical preform having its open upper or neck end of larger diameter than its closed bottom end. The supply block 40, sleeve 42, injection piston 50 and plastic supply piston 63 are all substantially the same as illustrated and described in conjunction with Figs. 1 to 4.

One other difference resides in the blow tube 95. More specifically, the lower portion of the blow tube is provided with an exterior peripheral surface 96 which is downwardly and inwardly tapered to conform to the taper of the mold cavity 33. The blow tube is provided with a cylindrical bore 97 through which a valve rod 98 projects to carry a valve head 99 cooperating with the annular lower extremity 100 of the blow tube 95 to control the flow of air therethrough.

As illustrated in Fig. 9 of the drawings, following the injection molding of the blank or preform, the blow tube 95 may be moved upwardly relative to the remainder of the apparatus prior to stripping of the injection molded preform from the main or body mold 21.

Alternatively, if desired, the blow tube may be retained in its position of Fig. 8 relative to the valve rod 98 until after removal of the injection molded preform from the mold 21. In any event, upon closure of the blow mold segments 70 on the preform, fluid under pressure introduced through the bore 97 of the blow tube will freely enter the injection molded preform to inflate the same against the walls 72 of the blow mold segments 70.

The neck or finish portion of the injection molded preform, while still confined and supported at its outer periphery by the neck mold segment 26, has its inner periphery exposed to the blow air internally of the preform. In this manner, improved air distribution and cooling of the blown article by the blow air, and even internal cooling of the injection molded neck portion, can be obtained.

THE EMBODIMENT OF FIGURES 11 TO 13

In each of the three previously described embodiments of the invention, the blowing has been accomplished through a tubular element which forms a portion of the injection mold during the injection molding operation. Further, during the removal of the injection molded blank or preform from the injection mold and during the position-

ing of the preform in the blow mold, the preform is supported by the blow tube or the valve element associated therewith.

Figs. 11 to 13 provide an apparatus which is a substantial departure from those previously described inasmuch as a separate blow head is utilized.

More specifically, the injection molding apparatus of Fig. 11 is quite similar to that of Fig. 8 heretofore described, with the exception that the inner or mandrel member of the injection mold cavity is defined by a solid rod or mandrel 105 rather than by a blow tube. Of course, if desired the mandrel may be provided with coolant passages or resistant heaters as necessary.

After formation of the injection molded preform 106, the preform is stripped from the main mold 21. The preform 106 is supported by the neck mold segments 26, or, if desired or necessary, additionally supported by either the mandrel 105 or the injection piston 50 or both. Following such removal, the mandrel 105 is moved axially from the preform, as best shown in Fig. 12 of the drawings, with the preform 106 still being supported by the neck mold segments 26 and by the insert or collar 90. It will be noted that the collar 90 is provided with an inner, generally cylindrical extension 107 which projects downwardly into the injection molded neck or finished portion 108 of the preform to thereby form the inner periphery of the neck. Also, the extension 107 cooperates with the inner periphery of the neck mold segments 26 to confine the upper portions of the preform 106 therebetween, thereby making possible the support of the preform solely from the neck mold segments 26 and the collar 90 as best illustrated in Fig. 12.

Following stripping of the preform, the lower portions of the preform are enclosed in blow mold segments 70 and a blow head 111 is inserted into the collar 90. This blow head or blow tube 111 has an exterior diameter substantially less than the interior diameter of the collar 90. To seal the blow tube 110 within the collar 90, a resilient, preferably elastomeric annular seal ring 112 is carried by the blow tube 110 to surround a medial portion thereof. When this seal ring 112 is snugly interposed between and in sealing engagement with both the exterior periphery of the blow tube and interior periphery of the collar 90 following insertion of the blow tube, the preform can be blown to its final configuration. Of course, such blowing does not disturb the upper or neck portion of the final article inasmuch as such portions 108 are confined between the segmental neck mold 25 and the lower portions 107 of the collar 90.

Preferably, the blowing of the injection molded preform 106 by means of the separate blow head 111 is accomplished immediately after injection molding of the preform and prior to sufficient cooling of the preform for it to be set or hardened to such an extent that blowing is no longer possible. However, in the event that hardening does occur, the preform can be reheated for the purpose of blowing without departing from the basic concepts of the present invention.

By utilization of a separate blow head, a greater degree of flexibility in the apparatus and the process can be obtained and the process may be better adapted to consecutive injection molding, stripping and blowing steps performed, for example, on a rotary table.

THE EMBODIMENT OF FIGURES 14 TO 16

In that embodiment of the invention illustrated in detail in Figs. 14 to 16 of the drawings, the apparatus of Figs. 8 to 10 has been modified for utilization in conjunction with a substantially cylindrical blank or preform wherein blowing is not effective upon the neck or finish portion of the container.

More specifically, a truly cylindrical blow tube 115 is utilized, rather than the tapered blow tube 95 of the earlier described embodiment.

Further, the sleeve 82 of Figs. 5 to 7 is utilized as the main injection mold in which the preform is made. A valve rod 116 having a lower cylindrical valve head 117 cooperating with the lower annular extremity 118 of the blow tube 115 is utilized. The injection molding is carried out substantially as described in conjunction with Fig. 5 of the drawings, and stripping of the preform can be accomplished either as described in connection with Fig. 6 of the drawings or in connection with Fig. 9 of the drawings, that is, either with the valve head 117 contacting the lower extremity 118 of the tube 115 or with the tube vertically withdrawn upwardly from contact with the valve head.

In either event, following enclosure of the preform within the blow mold segments 70 and during the subsequent blowing step, the blow tube 115 is retracted only to such an extent that it is flush with the lower extremity of the neck mold, so that the upper or finish portion of the final article is continuously confined between the neck mold and the blow tube during blowing.

THE EMBODIMENT OF FIGURES 17—21

In that embodiment of the invention illustrated in Figs. 17—21, inclusive, a preferred method of the present application is illustrated.

As illustrated in Fig. 17 of the drawings, an injection molded blank or preform 120

is formed in a mold cavity defined by separable injection mold halves 121 closable in surrounding relation around the cylindrical upper extremity of the injection ram sleeve 42 projecting beyond the confines of the block 40. Superimposed on the injection mold halves or segments 121 are a pair of laterally separable neck molds 122 having their mating, neck-defining surfaces appropriately contoured, as at 123, to define the finished neck portion of the container.

These neck molds surround a neck bushing or sleeve 125 having an inner cylindrical surface 126 and an outer lower surface including an upper cylindrical portion 127 defining the inner cylindrical surface of the neck and a lower tapered portion 128. Projecting axially through the neck bushing 125 is an injection mold core sleeve 130. This core sleeve is provided with an upper cylindrical portion 131 snugly peripherally contacting the inner cylindrical surface 126 of the neck bushing and with a lower tapered portion 132 forming a continuation of the tapered surface 128 of the neck bushing. The core sleeve is provided with a cylindrical lower opening defined by an end surface 133 thereof which abuts the enlarged head 134 of a core pin 135.

This head 134 cooperates with the core sleeve 130 to define the inner core of the injection mold space within which the preform 120 is formed. The outer surface of the preform is defined by the tapered cavity formed by the inner surfaces 124 of the injection mold segments 121. The bottom of the injection mold is formed by the injection piston or ram 50 spaced from the core pin head 134 by the material introduced into the mold cavity by the ram 50 as heretofore described. Also, as in earlier described embodiments of the invention, the rounded lower corners of the preform 120 are defined by the upper inner surfaces 42a of the ram sleeve 42.

When the segmental molds 121 are closed in their positions illustrated in Fig. 17, the ram 50 displaces upwardly that plasticized material previously introduced into the sleeve 42, and this material is displaced into the mold.

Next, as illustrated in Fig. 18 of the drawings, the injection molded preform is removed from the injection mold 121. This may be accomplished by opening the separable mold segments 121 or by vertical displacement of the preform relative to the block 40 and the molds 121. In any event, the preform is still supported by the neck molds 122 and by the neck bushing 125.

After separation of the preform 120 from the injection molds 121, air from the interior of the core sleeve 130 is introduced into the preform 120 by retraction of the core sleeve. Upon initial upward displacement of the core sleeve, the lower end surfaces 133 of the sleeve will be moved from their abutment with the core pin head 134 and air in the interior of the core sleeve will pass therebetween into the preform 120.

Due to the taper of the core sleeve and the corresponding taper of the preform, initial movement of the core sleeve will space the entire core sleeve exterior periphery from the inner periphery of the preform as through a space 136. Air introduced into the preform will enter this space and will prevent collapsing of the preform as the tapered core sleeve is retracted. Further, such air will materially aid in stripping the core sleeve from the interior of the preform 120. It will be noted that the upward retraction of the core sleeve does not effect movement of the core pin, and the core pin head 134 remains in contact with the bottom of the preform. Thus, the preform 120 is supported at both the inner periphery and the outer periphery of the neck portion thereof and the preform is also engaged at its lower interior surface by the core pin head 134. Additionally, the inner cylindrical peripheral surface 126 of the neck bushing 125 and the upper cylindrical portion 131 of the core sleeve remain in full peripheral contact despite upward displacement of the core sleeve, thereby preventing leaking of air from the interior of the core sleeve except into the interior of the preform.

Upon further retraction of the core sleeve, the relative positions of Fig. 19 are attained in which it will be seen that the preform has been partially inflated by the low volume, low pressure air introduced into the interior thereof, and it will be further noted that the interior surface of the preform is now free of the tapered exterior surface 128 of the neck bushing 125. At the same time, the preform remains supported both interiorly and exteriorly at its neck portion and at its lowermost extremity by means of the core pin head.

Next, separable blow mold segments 137 are closed on the preform beneath the neck molds 122, and the preform is inflated by high pressure blow air introduced through the core sleeve 130 against the inner wall surfaces 138 of the segmental blow molds 137 defining a cavity corresponding to the final article shape. During the blowing, the lowermost portion of the preform is finally stripped from the undersurface of the core pin head 134.

It will be noted that the undersurface of the core pin head is spaced only slightly from the bottom wall surfaces 139 of the blow mold segments, and that the material formerly contacting the core pin head 134 travels only a very short distance into contact with these blow mold wall portions

139. In this manner, the blow molding of the article is substantially completed prior to stripping of the preform from the core pin head and the preform is engaged and centralized in a truly vertical position (by its contact on the core pin head together with its continued support at the neck portion thereof) until blow molding is substantially complete.

Finally, the neck bushing 125, the core sleeve 130 and the core pin 135 are completely retracted from the interior of the finished article and the article is supported by the neck rings 122 only until such time as the neck rings are opened. At this time, the finished article is completely released from the apparatus.

APPARATUS

In Figs. 22 to 41 there is illustrated an apparatus capable of carrying out the methods heretofore described. This apparatus will be described particularly in connection with the process of Figs. 17—21.

Fig. 22 is an overall view of the apparatus and upon which the various portions of the apparatus are illustrated by reference numerals hereinafter mentioned.

As hereafter described in detail, the apparatus consists generally of a plasticized material accumulator for metering plasticized material to an injection ram, the injection ram for displacing the plasticized material into the injection molds, the injection molds including separable peripheral preform molds, neck molds and injection mold core structure for defining a complete parison cavity, means for displacing the injection molded preform to a blow molding station, and blow molds at the blow molding station. The complete apparatus is under the control of hydraulic, pneumatic and electric control systems for properly correlating the various steps of the method and for overlapping certain steps of the method to reduce the overall cycle time.

PLASTICIZED MATERIAL ACCUMULATOR STRUCTURE

As best illustrated in Figs. 23—29 of the drawings, plasticized material is supplied to the machine of the present invention by means of a plasticizer screw 150 operating within a plasticizer barrel 151 to reduce pelletized or other solid plastic material to a fluid, plasticized state by the time the material attains the exit end of the screw.

The exit end of the screw communicates with an elongated material passage 152 formed interiorly of a cylindrical feed tube 153 adapted to be heated by exterior peripheral electrical resistance heating elements 154. The material passage 152 communicates by a port 158 with a transverse valve bore 155 in which is positioned a valve sleeve 156 having an axial bore 57 communicating freely with the vertical bore 160 of a ram sleeve 161 in which the injection ram (hereinafter described) is vertically reciprocated. The sleeve 161 is seated in a concentric vertical bore 162 formed in an accumulator block 163, this same block being bored to provide the valve sleeve bore 155 and the extreme end 158 of the material passage 152.

Longitudinally or axially reciprocable in the bore 155 of the valve sleeve 156 is a plastic flow control valve indicated generally at 165. This valve 165 is cylindrical in configuration and is provided with a medial reduced diameter groove 166 of axial extent sufficient to bridge the space between the material inlet passage 158 and an accumulator inlet passage 167 formed in the block 163, when the valve is positioned as illustrated in Fig. 23. The valve 165 is provided with an arcuate leading end 168 struck on a radius equal to the radius of the ram sleeve bore 160, so that the free end 168 of the valve 165 blends smoothly with the bore 160 when the valve is positioned as shown in Fig. 23. Both the valve sleeve 156 and the valve 165 are fixed against rotation.

The accumulator inlet passage 167 communicates with a generally cylindrical accumulator space 170, the space being tapered toward its outlet end at which an accumulator outlet passage 171 is provided. This outlet passage 171 communicates with the bore 155 of the valve sleeve 156 intermediate the material passage 158 and the ram sleeve bore 160.

Disposed within the accumulator space 170 for axial displacement therein is an accumulator piston 172 having a tapered nose 173 conforming in contour to the tapered end of the accumulator space. This piston 172 is guided for axial displacement in a guide sleeve 174 concentric with and partially defining the inlet portion of the accumulator space 170 and secured to the accumulator block 163 by suitable means, as by screws 175.

The accumulator ram 172 is provided with a medial cylindrical portion 176 disposed exteriorly of the accumulation space 170 and the accumulator block 163 and projecting axially into a cylindrical block 177 having an interior cylinder cavity 178 of slightly larger diameter than the medial portion 176 of the ram 172. The ram portion 176 is joined by a reduced axially elongated extension 179 to a threaded terminal portion 180 bearing an adjustable nut 181; this nut abutting the rear extremity 182 of a sleeve 183 enclosing and guiding the portion 179.

The ram 172 is supported for axial or longitudinal displacement from its forward-

most position illustrated in Figs. 23 and 26 to its rearmost position illustrated in Fig. 27. Such axial displacement of the ram is guided by the guide bushing 174 adjacent the forward end thereof and by the cylindrical guide member 183 engaging the cylindrical extension 179 adjacent the rear end thereof. The cylinder space 178 is adapted to receive hydraulic fluid through a conduit 184 (Fig. 25), the introduction of fluid pressure into the space 178 through the conduit 184 displacing the accumulator ram 172 to the right (to its illustrated position of Fig. 23) by the exertion of fluid pressure onto the rear radial face 185 of the piston portion 176 of the ram 172. As will be hereinafter more fully described, the introduction of plasticized material into the accumulation chamber 170 will act upon the free forward end 173 and the accumulator ram 172 and will displace the ram rearwardly to its illustrated position of Fig. 27.

The rear guide sleeve 183 is provided with an air passage 186 (Fig. 25) connected to a suitable source of compressed air through a conventional diaphragm-actuated pressure switch by means of air conduits 187 so that the diaphragm of the pressure switch will be subjected to actuating air pressure when the nut 180 closes that end of the passage 186 opening onto the rear face 182 of the sleeve 183, otherwise air within the conduit 186 will escape freely therefrom. The conduits 187 are connected to a pressure switch identified as PS1. Actuation of this switch PS1 indicates abutment between the nut 181 and the sleeve 183, thereby indicating that the ram 172 is in its forwardmost position and the accumulator chamber 170 is discharged (illustrated in Figs. 23, 26 and 28).

An indication that the accumulator chamber is filled is afforded when an enlarged collar 188 located at the forward end of the piston portion 176 of the ram 172, abuts the free face 189 of a bushing 190 located at the forward end of the cylinder chamber 178. The bushing 190 is provided with an air passage 191 communicating with a pressure switch PS2 through air lines 192. Thus actuation of the pressure switch PS2 will occur upon abutment between the collar 188 and the face 189 of the bushing 190, thereby indicating that the ram is in its position of Fig. 27, the accumulator being filled with plasticized material.

Filling and emptying of the accumulator is, of course, under the control of the plasticized material flow valve 165. This valve 165 is actuated by a piston 195 joined to the valve by a rod 196, the piston being confined in a cylinder recess 197 formed in the cylinder block 177. The open rear end of the recess 197 is closed by a stop cylinder structure 198 defining an interior cylinder cavity 199 closed by a terminal cavity plug 199*a*.

Disposed within the cylinder cavity 199 is a stop piston 200 having a piston rod 201 projecting into the cylinder recess 197 for abutment with the piston 195 under certain operating conditions. By means of the piston 195 in combination with the stop piston 200, the valve 165 can be moved to the three operating positions illustrated in Figs. 26 to 28, respectively. In Fig. 23 and Fig. 26, the valve 165 is illustrated in its forwardmost or "closed" position, at which fluid under pressure is introduced through a port 202 into the rear of the stop cylinder recess 199 and through a port 203 into the rear of the actuating cylinder recess 197. Accordingly, the piston 200 is displaced forwardly and the piston 195 is also displaced forwardly out of contact with the piston rod 201 of the stop piston 200. Thus, the valve 165 is positioned to interconnect the plasticized material inlet passage 158 and the accumulator inlet passage 167 by means of the peripheral groove 166.

Under these circumstances, plasticized material flows into the accumulator and will displace the accumulator ram 172 rearwardly against the hydraulic resistance of fluid in the chamber 178, as hereafter more fully described. When the accumulator ram 172 has been displaced rearwardly and the accumulator is filled, the pressure switch PS2 will be actuated, as heretofore described. In accordance with the control system to be hereinafter more fully described, flow of pressure fluid through the port 203 is interrupted (in response to actuation of switch PS2) and pressure fluid is introduced through a port 204 to displace the piston 195 rearwardly.

It will be noted that the piston rod 196 joins the forward or right hand face of the piston 195. Therefore, the only area of piston 195 exposed to pressure fluid entering through port 204 will be the area of the piston 195 minus the area of the rod 196. This differential area is less than the area of the completely exposed rear face of the stop piston 200. Accordingly, pressure within the cylinder chamber 199 on the piston 200 will maintain the piston 200 in its right-hand or forward position even though the piston 195 is displaced rearwardly. Thus, the valve 165 will be stopped in its mid-position (that position illustrated in Fig. 27 of the drawings) wherein the valve groove 166 is positioned to the left of the material inlet passage 152, so that no more material will be introduced into the accumulator space 170. At the same time, the forward or free end 168 of the valve 165 is still interposed between the sleeve bore 160 and the outlet passage 171, so that plasticized

material cannot escape from the accumulator space 170.

When there is a demand for plasticized material in the sleeve bore 160, the flow of pressured fluid through the port 202 is interrupted and the port is vented to the sump. Piston 195 can now move to the rear under the pressure of fluid introduced through the port 204, thereby moving the valve 165 to its position illustrated in Fig. 28 of the drawings which is its "open" position.

At this open position, the forward face 168 of the valve 165 is retracted to uncover the outlet passage 171 and plasticized material is allowed to escape from the accumulator space 170 and into the sleeve 160 through the bore 157 of the valve sleeve 156. At the same time, fluid pressure in the chamber 178, introduced thereinto through the conduit 184, will displace the accumulator ram 172 forwardly into the accumulator space 170.

To correlate the movement of the valve 165 with the remainder of the apparatus, the piston rod 196 carries a transversely projecting bracket arm 205 provided with a rearwardly extending actuating arm 206. This actuating arm is provided with an adjustable abutment 207 at its extreme rear end for actuating a push-type limit switch LS4 mounted on a bracket 208 secured to the cylinder block 177. The actuating arm 206 also carries a pair of longitudinally adjustable actuating cams 209 and 210 for actuating additional push-type limit switches LS5 and LS6 also carried by the cylinder block 177.

The heretofore described accumulator arrangement affords very accurate metering for material from the accumulator into the sleeve bore 160. The threaded adjustment of the nut 181 upon the threaded shank 180 of the accumulator ram 172 affords means for accurately positioning the accumulator ram 172 within the accumulator space 170 at the forward or dispensing end of the accumulator ram stroke. When this accuracy of adjustment is coupled with the extreme accuracy of the pressure switch PS1, it will be readily appreciated that the position of the ram 172 may be adjusted with extreme accuracy.

Secondly, it will be noted that the ram does not engage the side walls of the accumulator space, but rather cantilevers freely into the ram space, thereby avoiding the necessity of sealingly engaging the hot plasticized material with a sealed piston. Thus, leaks past the accumulator piston are avoided and frequent replacement of seals is not necessary.

Further, upon completion of the forward stroke of the ram 172, the valve 165 is moved to its position of Fig. 23 so that any material trapped between the leading face 168 of the valve and the bore 160 is displaced by the valve face into the bore. The contouring of the valve face 168 to the periphery of the bore ensures the full scraping of all of the material from the valve face by the injection ram.

It will also be noted that the flow of material from the plasticized material passages 152 and 158 through the valve groove 166 and into the accumulator space 170, and from the accumulator space into the sleeve 160 is always in a forward direction. There are no pockets or dead areas in which the accumulated material may congregate. The utilization of material from the plasticizer screw 150 to move the accumulator ram rearwardly against back pressure, as hereinafter described, ensures that the material located within the valve groove 166, the inlet port 167, and intermediate the ram and the walls of the accumulator space is displaced forwardly ahead of the ram as the accumulator space is filled for the next dispensing operation.

INJECTION RAM

As illustrated in Figs. 29 and 32, the machine includes a machine base 211 provided with upright columns or supports 212 supporting an upper table element 213. Depending from this table element 213 and secured thereto is the accumulator block 163 heretofore described. This block 163 has the vertical bore 162 therein to receive the injection sleeve 161, the bore 160 of which communicates through bore 157 with the accumulation chamber. The sleeve 161 thus is secured to the table element 213 to depend therefrom through the accumulator block 161.

Also carried by the table element 213 is a vertically disposed guide rod 214 which is also secured to the base 211 for guiding a vertically reciprocal ram cross head 215. This cross head 215 is further guided for such vertical movement by additional guide elements including elongated guide rods 216 having downwardly facing stop shoulders 217 thereon.

The cross head 215 is actuated for vertical displacement by a fluid pressure actuated cylinder 218, the piston rod 219 of which is secured to the cross head 215 by suitable means, as by threads 220. Located centrally of the cross head 215 is a mounting block 221 surmounted by a cap 222 confining therein the lower extremity of a piston structure indicated generally at 223 and including an elongated tubular piston body 224 surmounted by a hollow piston head 225.

Extending axially through the piston body 224 is a fluid inlet tube 226 communicating with a source of coolant, such as water under

pressure, through an inlet conduit 227 carried by the cap 222. Also carried by the cap 222 is a fluid outlet tube 228 communicating with the annular space between the tubular piston body 224 and the inlet tube 228. From this structure, it will be readily apparent that fluid introduced through the inlet tube 227 will pass upwardly through the inlet tube 226 to impinge upon the undersurface of the hollow piston head 225, the water then draining down between the inlet tube 226 and the piston body 224 for egress through the outlet tube 228.

It will be seen that in the lowest position of the cross head 215, the piston head 225 is in the lower end of sleeve 161, specifically within the bore 160 thereof. Upon actuation of the cylinder 218, the piston rod 219 will be extended by the cylinder to raise the cross head 215, guided by the guide element 214, to elevate the piston for passage through the bore to pick up the plasticized material introduced into the bore through the accumulator bore 157. This movement of the piston is further guided by means of a guide sleeve 229 depending from the accumulator block 163 and having at its lower end a guide bushing 230 snugly embracing the tubular piston body 224.

When the cross head 215 is in its lowermost position, an adjustable abutment 231 contacts a fixed limit switch LS3 secured to the machine base 211 by means of a mounting arm 232. When the cross head 215 is in its uppermost position, a limit switch LS1 (Fig. 32) is actuated by an adjustable cam 233 carried by a depending support rod or arm 234 on the cross head, the limit switch LS1 being also carried by the arm 232. The shoulders 217 on the rods 216 serve as a safety stop to prevent overtravel of the ram 223.

NECK MOLDS AND INJECTION MOLD CORE STRUCTURE

Superimposed over the support table 213 in spaced relation thereabove and carried by the vertical supports 212 is a lower or neck mold cross head 235 (Fig. 33). This cross head consists of a generally rectangular steel block having a central vertical bore 236 and vertical side bores receiving vertical guide elements 244 so that the cross head is vertically displaceable.

Secured to the undersurface of the cross head 235 are transverse support blocks 237 disposed one on each side of the vertical axis of the bore 236. Secured to each of these blocks is a neck mold actuating cylinder 238, the cylinders each having an inwardly projecting piston rod 239 terminating in neck mold carrying blocks 240 upon which are carried the complementary neck mold segments 241, the segments having complementary internal surfaces 242 appropriately contoured to cooperatively define the entire outer periphery of the neck of the container to be formed. It will be appreciated that the neck mold cylinders 238, when retracted, open the complementary neck mold sections 241 and, when closed, define the outer periphery of the neck mold cavities. The neck mold sections 241, when closed, are located circumferentially by a bushing 235*a* carried by the cross head 235 in the bore 236.

The neck mold cross head 235 is interconnected with a main cross head 243 for co-movement therewith on the vertical guide rods 244 secured to the support plate 213. This main cross head 243, and the neck mold cross head 235 are adapted to be vertically reciprocated on the guide rods 244 by a single large overhead cylinder 245 carried by upper, heavy frame cross members 246 secured to and surmounting the vertical frame members 212, as best illustrated in Fig. 22.

Intermediate the main cross head 243 and the neck mold cross head 235 is a core cross head 250. This core cross head 250 is adapted to be vertically reciprocated on vertical guides 251 by means of a pair of vertically extending cylinders 252 having their piston rods 253 secured to the cross head 250, as through blocks 254, these two cylinders 252 also being carried by the main frame cross members 246, also as best shown in Fig. 22. Again, it should be emphasized that the neck mold cross head 235 and the main cross head 243 travel together and are actuated by the single cylinder 245, while the core cross head 250 travels independently of the other cross heads as determined by actuation of the pair of cylinders 252.

Carried by the main cross head 253 to depend therefrom is a vertical, cylindrical core pin 255. This core pin is best illustrated in Fig. 34 of the drawings and is formed of rod stock, the core pin carrying at its lower end a radially enlarged head 256 having an upper planar surface 257, a peripheral, slightly conical exterior wall 258 and a lower flat surface 259. While the core pin is vertically displaceable with the main cross head 243, it is also supported for slight movement relative thereto by means of a coiled compression spring 260 bottomed in a recess 261 formed in the cross head and bearing against a flanged cap 262 rigid with the pin. The purpose of this relative movement will be hereinafter described in greater detail.

The core cross head 250 is provided with a central vertical bore 263 accommodating the passage of the core pin 255 therethrough. This bore 263 is closed at its upper end by a cap 264 sealingly engaging the core pin, as by an O-ring 265, and having a downwardly opening recess 266 com-

municating with the bore. Projecting into this bore 263, and sealed therein by an O-ring 267, is the free upper end of an inner core sleeve 268 concentric with the core pin 255 and spaced peripherally therefrom to define a restricted annular space 302 therebetween. Concentric with the inner core sleeve 268 is an intermediate core sleeve 269 also concentric with the core pin 255 and spaced from the lower end of the cap 264 by means of a coiled compression spring 270. The sleeve 269 is spaced radially from the inner sleeve 268 to define therebetween an annular flow passage 303.

The cap 264 serves to introduce air into the annular space 302 defined intermediate the inner sleeve 268 and the core pin 255, the seal ring 265 carried by the cap and engaging the core rod and the ring 267 around the sleeve 268, confining the blow air to this annular zone.

Passage 303 serves as a coolant passage, receiving coolant fluid from a bore 305 in the head 250, as best shown in Fig. 34. Coolant introduced into the passage 303 flows downwardly between the intermediate sleeve 269 and the inner sleeve 268. Egress of such coolant is provided by a passage 304 formed intermediate the outer periphery of the intermediate sleeve 269 and the inner periphery of a sealing sleeve 271 sealingly engaging a counterbore 272 in the cross head 250, as by a seal ring 273, thereby sealingly communicating with water egress passage 274.

Surrounding the sealing sleeve 271 is an outer core sleeve indicated generally at 275 and having an out-turned, radially enlarged peripheral flange 276 secured in abutment with the undersurface of the core cross head 250 by suitable means, as by undercut securing brackets 277. This outer core sleeve is provided with an intermediate truly cylindrical peripheral portion 278 projecting fully beyond the lower extremities of the neck molds 241 and merging therebeneath, as at 279, into a conical peripheral surface 280, the conical peripheral surface terminating in a planar horizontal end surface 281 snugly abutting the upper surface 257 of the core pin head 256 (Fig. 34).

It will be noted that the outer or seal sleeve 271 terminates within the cylindrical portion of the core sleeve 275, as at 282. The intermediate sleeve 269 depends into the frusto-conical portion 280 of the core sleeve 275, the lower end of this sleeve 269 being provided with radial slots 283 to establish communication between the annular space intermediate the sleeves 269 and 268 and the interior of the core sleeve 275. The inner sleeve 268 terminates adjacent the core pin head 256, the lower end of the sleeve 268 being sealingly seated on a shoulder 284 formed in the core sleeve 275.

Snugly surrounding the upper cylindrical surface 278 of the core sleeve 275 and disposed interiorly of the cylindrical bushing 235*a* of the cross head 235 is a generally cylindrical water jacket 285 having an interior downwardly opening recess 286 at the inner periphery thereof within which is mounted a neck core sleeve 287. This neck core sleeve 287 has an upwardly projecting cylindrical flange 288 positioned in the recess 286 and a radial medial flange 289 projecting radially beneath the water jack 285. The neck core sleeve 287 has a depending flange 290 snugly abutting the lower periphery of the cylindrical surface 278 of the core sleeve 275. This core sleeve flange 290 terminates in a lower knife edge joined to the flange 290 by a conical surface 291. This surface 291 is of the same inclination as the outer surface 280 of the core sleeve 275 cooperatively define a smooth frusto-conical surface.

The laterally projecting or radial flange 289 of the core sleeve 287 is provided with a terminal upwardly projecting shoulder 292 which is bottomed against and secured to the water jacket 285. This water jacket is provided with a radially enlarged shoulder 293 abutting a supply block 296 carrying water inlet and outlet couplings 297, the water passage 295 of which communicates with a water passage 294 which projects downwardly through the jacket 285 into fluid communication with the neck core flanges 289.

The blocks 296 have secured thereto a plurality of stripper pins 298 which project upwardly toward the main cross head 243 (Fig. 33). Interposed between the main cross head 243 and the stripper pins 298 are a plurality of compression springs 299. The dead height of the springs 299 is such that movement of the core cross head 250 upwardly relative to the main cross head 243 through the movement accommodated by the springs 299 will strip the neck core 287, particularly the lower neck core flange 290 from the injected neck of the article as retained by the neck molds 241. This operation is obtained by contact of the free upper surface of the core cross head 250 with the undersurface of embossments 300 formed on the pins 298, respectively, and confining the springs 299 against the undersurface of the main cross head 243.

To review briefly the movement of the cross heads, it will be recalled that the main cross head 243 and the neck mold cross head 235 move together and are actuated by the upper cylinder 245. The core cross head 250 is moved independently of the other cross heads by the cylinders 252. The main cross head carries the core pin 255, the neck mold cross head carries the neck molds 241 which are independently actuated

by their own cylinders 238, and the core cross head 250 carries the outer core sleeve 275 together with the inner sleeve 268, the intermediate sleeve 269, and the sealing sleeve 271. The neck core sleeve 287 normally abuts the upper surface of the neck rings 241 and is carried for movement by the jacket 285.

As best shown in Fig. 34 of the drawings, cap 264 surmounting the core cross head 250 is apertured, as at 301, to receive air from a suitable source, hereinafter described. This air enters the chamber 266 and subjects the annular passage 302 intermediate the inner sleeve 268 and the core pin 255 to air from the aperture 301. This air is valved by contact between the core pin head 256 and the undersurface 281 of the sleeve 275. Heat exchange fluid, introduced into the second annular passage 303, flows from the passage 303 into the outer sleeve 275 and flows upwardly therefrom through the slots 283 in the bottom portion of the intermediate sleeve 269 for return through passage 304 intermediate the sealing sleeve 271 and the exterior periphery of the intermediate sleeve 269 for egress through the radial passage 274. As best illustrated in Fig. 34 of the drawings, the heat exchange fluid is introduced into the chamber 263 by the passage 305.

As illustrated in Fig. 35 of the drawings, the cross heads 243 and 235 carry a plurality of vertically projecting adjustment rods 308, the adjustment rods carrying actuating cams 309 for limit switches LS11—LS14, inclusive. Limit switches 11, 12 and 13 are carried by the core cross head 250, while limit switch LS14 is fixed to the mounting frame.

To indicate positioning of the cross head 250 in its extreme positions, a pressure switch PS6 is actuated when the head is down and a pressure switch PS7 is actuated when the head is up. Similarly, a switch PS8 indicates when the cross heads 243 and 235 are fully down and PS9 is actuated when the cross heads are up. These switches PS6, 7, 8 and 9 are similar to the switches PS1 and 2 heretofore described.

Assuming that the cross heads 243, 250 and 235 are in their down positions at which the complete injection mold is defined, the movement of the cross heads is as follows:

1. Initially, all three of the cross heads 235, 243 and 250 move upwardly in unison to transfer the injection molded parison to the blowing station.

2. As the three cross heads are jointly displaced, the core cross head 250 moves upwardly relative to the other two cross heads. In effect, the core cross head 250 moves from its position of Fig. 33, moving the core sleeve 275 away from the core pin head 256 and stripping the core sleeve from the interior of the injection molded parison. At this time, air from the passage 301 in the cap 264 passing through the passageway 302 is effective to inflate the injection molded parison to a limited extent. The heat exchange fluid within the passages 303 and 304 is completely sealed within the core and thus can remain on for heat exchange control.

3. At the blowing station, the blow molds are closed onto the parison and are blown and the parison is blown to its final configuration.

4. Following completion of the blow molding operation, the blow molds are opened and the core cross head 250 moves upwardly to completely remove the core 275 from the parison. At this time, the core cross head 250 contacts the undersurfaces of the abutments 300 on the stripper pins 298 and pulls the sleeve 285 and the neck core sleeve 287 upwardly from the interior of the injected neck. Following this operation, the neck molds 241 are opened by operation of their cylinders 238 and the blow molded article is released.

PARISON MOLD STRUCTURE

As best illustrated in Figs. 36 and 37 of the drawings, a pair of longitudinally reciprocable parison molds 310 are provided. These parison molds each comprise support blocks 311 having centrally located, vertically extending bores 312 within which are positioned parison mold inserts 313 which define the actual parison mold cavity portions 314. The inserts 313 are retained in the blocks 311 by suitable means, as by screws 315.

The blocks 311 are horizontally slidable from their open positions (shown in Fig. 36) to their closed position (shown in Fig. 37) on horizontal guide rods 316 secured to the vertical machine supports 212 by suitable means, as by support blocks 317. These support blocks 317 are secured, as by tension bolts 318 and nuts 319, to parison mold cylinders 320. These parison mold cylinders 320 have their piston rods 321 secured to the mold blocks 311 by suitable means, as by support brackets 322. Actuation of the cylinders 320 will open and close the parison mold inserts 313, the inserts abutting along surfaces 323 of the inserts 313.

Leading to one of the surfaces 323 is a reduced air passage 324 communicating with an air supply passage 325 leading to a pressure switch PS3 similar to the pressure switches PS1 and PS2 heretofore described. The switch PS3 will be actuated when the parison mold inserts 313 are in abutment, the pressure switch thus being indicative of formation of the parison mold cavity. The mold inserts 313 are maintained at a con-

trolled temperature by heat exchange fluid introduced through main heat exchange flow passages 326 formed in the blocks 311 and communicating with secondary flow passages 327 formed in the inserts 313.

Carried by each of the mold blocks 311 is a limit switch actuating arm 330 having an actuating cam 331 adjacent the rear end thereof, this cam being displaceable with the corresponding mold block 311 for actuating a limit switch. One of the limit switches is hereinafter referred to as limit switch LS8, while the other of the blocks 311 is provided with a limit switch LS7, the limit switches each being carried by a bracket arm 332 secured to the mounting blocks 317.

BLOW MOLD STRUCTURE

Mounted generally above the parison molds 310 are a pair of cooperable blow mold segments 340. These blow mold segments are carried on links 341 and 342 pivotally connected at their upper ends, as at 343 and 344, respectively, to the undersurface of the main upper structural support member 246 surmounting the vertical support columns 212. The links are each pivoted individually at their lower ends as at 345 and 346, respectively, to portions of the blow mold segments spaced horizontally the same distance as the pivot points 343 and 344, respectively.

Clamped to the vertical support columns 212 are transverse support frames 347 having rearwardly projecting spaced trunnion brackets 348 suspending therebetween pivot trunnions 349 pivotally supporting blow mold actuating cylinders 350. The cylinders 350 have their actuating rods 351 projecting forwardly between the supporting clamps 347 for pivoted attachment to the rear surfaces of the blow mold segments 340.

Thus, actuation of the cylinders 350 to displace the rods 351 forwardly will swing the blow molds 340 into closed engagement as shown in solid outline in Fig. 38, while retraction of the rods 351 by the reverse actuation of the double acting cylinders 350 will swing the blow molds to their open positions, as shown in dotted outline in Fig. 38.

The blow mold segments 340, of course, cooperate to define an interior cavity identical in overall outline to the blown portion of the container or other article being blown therein, as previously described.

The outer links 342 actuate individual limit switches LS9 and LS10 surmounting the respective mounting brackets, these limit switches thus giving an indication of opening of the blow molds. Additionally, one of the blow mold segments is provided with a pressure switch conduit, as heretofore described in connection with the parison molds, this conduit being effective to actuate a pressure switch PS4 when the blow molds are in their closed positions illustrated in solid outline in Fig. 38.

HYDRAULIC, PNEUMATIC & ELECTRICAL CONTROL SYSTEM AND OPERATION

As illustrated in Figs. 39 and 40 of the drawings, the mechanism herebefore described is controlled and operated by the illustrated hydraulic system. Additionally, a pneumatic control system as illustrated in Fig. 41 is also utilized. Figs. 30 and 31 disclose the electrical control system for actuating the various hydraulic and pneumatic mechanisms.

In order to simplify Figs. 39 and 40 of the drawings, the pump arrangement for supplying hydraulic fluid to the overall hydraulic system has been eliminated. As is conventional in large hydraulic control systems of the type here involved, several pumps of varying capacity are utilized to afford hydraulic fluid at varying pressures (through conventional relay valve arrangements) and at varying volumes (through conventional flow regulators and orifices). Since the purpose of illustrating the hydraulic, electric and pneumatic system is to disclose the sequence of operation, the specific hydraulic and electric supply arrangements have been deleted and fluid pressure line 400 and electric supply lines 399 are indicated schematically.

The following operation is premised upon the completion of a previous operating cycle, so that the accumulator chamber is full of plasticized material; the plastic valve 165 is in its mid-position of Fig. 27; the neck rings, parison mold sections and blow mold sections are opened; the mold core cross head and the machine main cross head are elevated; and the injection ram is retracted downwardly to its lowermost position.

Obviously, the first step is to introduce plasticized material into the ram chamber, the fluid material being carefully metered thereto by means of the mechanisms illustrated in Figs. 26, 27 and 28 of the drawings. Initially the condition of Fig. 27 obtains, i.e. with the plastic metering valve in its mid position shutting off communication between the plasticizer and the accumulation chamber and also shutting off communication between the accumulation chamber and the ram cylinder or metering sleeve. When the valve is in its mid position, fluid pressure is exerted through line 202 to the chamber 199 counter to pressure in chamber 197 from line 204.

The first step is to open the plastic valve 165 and this is accomplished by energizing

the valve V1 illustrated in Fig. 39 of the drawings and de-energizing valve V2. More specifically, a solenoid F is energized to displace the valve body V1 to the left, thereby placing the valve passage V1-1 in communication with the source of fluid pressure, i.e. hydraulic fluid in the hydraulic line 400. The hydraulic pressure is thus applied to line 204 and to the forward chamber 197 of the plastic valve cylinder 403. Return pressure from the rear end of the cylinder 403, i.e. in chamber 197 is passed through line 203 and valve passage V1-2 to the sump S. At the same time, pressure from the rearmost end chamber 199 of the cylinder 403 will be passed through line 202 to central valve passage V2-1 of valve V2 to the sump S, by de-energizing a solenoid D allowing the valve 165 to shift to its illustrated position from its mid position.

Turning now to Fig. 30 of the drawings, it will be seen that solenoid F of the valve V1 is energized by relay CR10, this relay CR10, in turn, being actuated by pressure switch PS2 which is moved against its upper contact by the accumulation chamber ram 172 when the accumulation chamber 170 is filled.

Thus, so long as the accumulation chamber 170 is filled, the relay CR10 energized and the valve V2 positioned as in Fig. 39, then solenoid F will be energized and the valve V1 actuated to move the plastic valve 165 to its "open" position illustrated in Fig. 28 of the drawings, i.e. a position in which communication is established between the accumulation chamber 170 and the injection ram sleeve 161.

Next, the accumulation chamber 170 is emptied of plastic material. This operation is accomplished by actuation of the valve V2, specifically by the solenoid C of valve V2 which is effective to displace the valve V2 to the right so as to interconnect the fluid supply line 400 through valve passage V2-2 with fluid line 404 leading into the accumulation chamber cylinder chamber 178. At the same time, the passage 202 continues to be connected to the drain or sump S by means of valve passage V2-3. The introduction of fluid under pressure into the accumulation cylinder chamber 178 displaces the accumulator plunger 172 to the right and displaces the material therefrom through the opened plastic valve 165 and the plastic valve passage 157 into the injection ram sleeve 161.

Referring again to Fig. 30 of the drawings, it will be seen that solenoid C is energized by relays CR9, CR37 and CR13 in series. The relay CR9 provides one of the primary interlocks of the electrical control circuit of the present invention, and its operation must be fully understood. It will be noted that actuation of this relay CR9 requires positioning of the plastic valve in its mid position (by limit switch LS5) and the closing of the automatic cycle of the machine during initiation of the relay CR9. However, the relay CR9 is provided with a holding contact bridging the limit switch 5 and the automatic cycle switch so that the relay will remain energized even when the limit switch LS5 is open.

Further, the relay CR9, for its initial and continued actuation, requires actuation of relay CR10 (responsive to the filled accumulator), CR17 (responsive to the parison molds 310 being open as indicated by limit switches 7 and 8), relay CR26 (responsive to the core pin being in its up position as indicated by pressure switch PS7), relay CR35 (responsive to the blow molds being open as indicated by limit switches LS9 and LS10), relay CR36 (responsive to the machine head 243 being up as indicated by pressure switch PS9) and relay CR37 (responsive to the position of the ram 223 when retracted) by means of limit switch LS3.

Thus, relay CR9 forms an interlock ensuring that the machine parison-forming components are open. It will be noted that relay contacts of CR9 bypass the limit switch LS5, thus movement of the valve 165 to its open position will not deactivate CR9 once it has been energized.

Solenoid C can also be held by relay CR12 as an alternative to CR9, however, relay CR12 requires prior actuation of CR9. The purpose of actuation from CR12 is to accommodate continued actuation of solenoid C and relays 12 and 11 therewith despite inactivation of the relay CR9.

Even though the relay CR9 is not required following initial actuation thereof and continued actuation of relay CR12, the relay CR37 requires the ram 223 to be in its lowest position by means of limit switch LS3 in direct circuit with the solenoid C. Also in direct circuit with the solenoid C is relay CR13, this relay being actuated by limit switch LS4, which is actuated only when the plastic valve 165 is in its open position of Fig. 28, thereby avoiding attempted discharge of material from the accumulation chamber by actuation of the accumulator piston 172 when the valve 165 is not in the proper position to accommodate such discharge. This requirement for actuation of the relay CR13 also applies to actuation of the relay CR11 which has a holding contact in parallel with a contact extending around the relay CR13.

Reviewing the action of the solenoid C, it will be seen that this solenoid is actuated to discharge the accumulator when the plastic valve 165 is moved to its open position by the control valve V1, and limit switch LS4 is closed. The holding of contact of relay R11 accommodates later movement of the plastic valve 165 from its open

position without deactivating the solenoid C until such time as the solenoid D for the valve V2 is energized as will be hereafter described.

Closure of the pressure switch PS1 upon emptying of the accumulation chamber energizes relay CR14. The relay CR14, together with relay CR10 (de-energized by opening of the pressure switch PS2) energizes solenoid E. PS2 is a two-position switch. In one position CR10 is energized. In its other position, CR1's holding circuit can be used. At the same time, solenoid F is de-energized by deactivation of the relay CR10. Thus, the valve V1 is shifted to the right. Such movement of the valve V1 connects the hydraulic fluid line 400 by valve passage V1—3 to fluid line 203 to displace the plastic valve 165 to the right, i.e. to its closed position (Fig. 26), while the valve passage V1—4 connects fluid line 204 with the sump S to accommodate such movement of the valve.

At substantially the same time that the plastic valve 165 is displaced to the right, from its fully open position, the solenoid D is energized to shift the valve V2 to the left. Such energization of the solenoid D will interconnect the fluid pressure line 400 with the fluid line 202 leading to the extreme rear chamber 199 of the plastic valve cylinder and will connect the accumulation chamber cylinder 178 with the sump S through valve passage V2—5, lines 407 and 184.

Closure of LS6 by movement of the valve 165 to the right energizes CR8, and the combination of CR14 and CR8 energizes CR1 to start the extruder motor. As the accumulator space fills, piston rod 172 is moved to the left whereby nut 181 no longer closes passage 186 so that the pressure switch PS1 opens to deenergize relay CR14 to open contacts CR14. However, CR1 is held energized by a holding circuit including contact CR1 of relay CR1 and switch PS2 to allow filling of the accumulator space. When the accumulator is filled, the motor is stopped by CR1 which is deenergized when PS2 is moved to its position in series with relay CR10. Thus, the accumulation chamber will be filled with plastic material under pressure, this pressure being determined by the back pressure developed against a valve 405 of conventional design interposed in the line 404 and having a by-pass incorporating a check valve 406 thereabove.

Considering now the actuation of the solenoid D to so move the valve V2 to the left, reference is made to Fig. 30 of the drawings, from which it will be seen that the solenoid D can be energized alternatively by normally closed contacts for the relay CR12 (responsive to the relay CR9) or by the relay CR14 (responsive to emptying of the accumulator by pressure switch 1). Simultaneously, solenoid C will be de-energized. This occurs when relay CR14 is actuated to also energize relay CR1 to start the extruder motor. Thus, the piston 176 can be moved to the left by the plastic.

After the emptying of the accumulator contents into the injection sleeve, or simultaneously therewith, which operation has been described in detail above, the neck molds 241 are clamped by means of the neck ring cylinders 238 (Fig. 40). These cylinders 238 are under control of a four way valve identified as V3 and actuation of the valve solenoid O will connect the rear ends of the cylinders 238 by fluid line 410 and valve passage V3—1 with the hydraulic fluid conduit 400. At the same time, valve passage V3—2 connects the forward ends of the cylinders to the sump S through lines 411.

The solenoid O for actuating the valve V3 is energized, as illustrated in Fig. 30 of the drawings, by means of relay CR26 (responsive to pressure switch PS7 closed by the presence of the core pin 255 in its up position), by relay CR9 (as above described) and by unactuated relay CR21, this relay being unactuated at any time that any one of the three relays CR38, CR29 and CR35, plus relay CR26, are not actuated. Relay CR38 is responsive primarily to non-actuation of the relay CR9; relay CR29 is responsive primarily to the blow molds being in closed position and a timer contact TM2 being closed; while relay CR35 is responsive to the blow molds being opened (as indicated by limit switches LS9 and LS10 being opened). So long as the relay CR21 is not energized, relay CR20 is actuated and remains energized by the closed position of the contacts of relays CR9 and CR26 which are energized through holding contact CR20, thereby maintaining the solenoid O energized.

The next successive steps of the operation involve the closure of the parison mold sections 310 by means of the parison cylinders 320 (Fig. 39). These cylinders are actuated by valves V4 and V5, the actuation of the cylinders preferably overlapping the introduction of plasticized material into the injection cylinder.

The initial step in actuation of the cylinders is the actuation of solenoid H of valve V4. This solenoid H when actuated shifts to the left the pilot valve PV1 so as to connect the hydraulic fluid supply line 400 by pilot valve passage PV1—1 and the pilot line 415 with control valve actuating cylinder 416. The control valve V4 is thus shifted to the left to interconnect line 400 with line 417 through the control valve passage V4—1. Line 417 branches into hydraulic lines 418 and 419, the line 419 dead-

ending at the central portion of pilot valve PV2 for the control valve V5, and line 418 branching into lines 420 and 421 by means of valve passage V5—1 in the central portion of control valve V5. Line 420 communicates with the rear ends of each of the parison cylinders 320 and serves to advance the parison pistons internally of the cylinders. Line 422 serves as a drain for the front ends of the cylinders 320.

By means of the control valve passage V5—1, regenerative circulation is obtained ensuring rapid traverse of the parison pistons in their inward directions. More specifically, the rear ends of the pistons have their complete surfaces subjected to pressure fluid entering thereinto through the lines 420 while the forward faces of the parison pistons have only that portion of their faces not blanked by the piston rods exposed to the same fluid pressure existing within the line 421. Accordingly, there is a net force displacing the parison pistons inwardly.

The drain fluid from the forward ends of cylinders will pass through the lines 422 and 421, the control valve passage V5—1 and back into the line 420. Thus, all of the fluid to displace the parison pistons need not come from the fluid line 400 and the pistons will be rapidly displaced inwardly under a force equal to the net force exerted on the blind and piston rod faces of the pistons, respectively. Thus, it will be seen that the parison mold sections are moved to their closed positions solely by actuation of the solenoid H.

This solenoid H is energized, as best seen in Fig. 40 by relay CR15. This relay CR15 is, in turn, actuated by relay CR9 (heretofore described and constituting the main interlock), CR36 (responsive to the machine head being in its up position through pressure switch PS9) and by CR37 (responsive to the position of the injection ram in its down position as determined by limit switch LS3). Thus, closure of the parison mold sections is determined by actuation of the solenoid H in response to the actuation of relay CR15.

After the parison molds have been moved to their closed positions, relay CR19 is energized in response to pressure switch PS3, this pressure switch being closed when the parison mold sections are in abutment, as heretofore described. At this time, the solenoid K will be actuated to shift the control valve V5 to the right.

More specifically, the solenoid K shifts the control valve PV2 to the left, to connect fluid pressure line 419 through valve passage PV2—1 to pilot line 425 so as to actuate control valve cylinder 426, displacing the control valve V5 to the left. In this manner, the fluid pressure line 418 is connected to the line 420 by the control valve passage V5—2 and the cylinder drain lines 422 and 421 from the front ends of the parison cylinders 320 are connected to the sump S by means of control valve passage V5—3. At this time, the outer end faces of the parison pistons are subjected to full line pressure through the conduit 420, and the inner faces of the pistons are vented to the sump S, thus clamping the parison molds 310 closed under full hydraulic force.

In order to form the injection or parison mold, the core cross head 250 must be lowered by means of the core cross head cylinders 252 (Fig. 40). This operation is accomplished by actuation of the solenoid P of pilot valve PV3. The solenoid P shuttles the pilot valve PV3 to the right so as to interconnect the main fluid pressure line 400 by means of pilot valve passage PV3—1 with a pilot line 430 for actuating control valve cylinder 431. Thus, the control valve V6 is shifted to the right, thereby interconnecting line 400 by valve passage V6—1 with hydraulic conduit 432 leading to the upper extremities of the core cross head cylinders 252.

Once again, the upper end of the core cylinders 252 communicate with the full end face of the pistons, while the undersurfaces of the pistons are of reduced area because of the presence of the piston rods 253. Thus, there is a net force downward upon the cross head cylinders even if the same pressure exists on both sides of the pistons. The undersurfaces of the pistons drain through conduits 433 into a line 435 with pressure relief valve 436 prohibiting drainage through line 437 and valve passage V6—2 to the sump S. A drain passage is afforded through conduit 438 and valve V7 as hereafter described.

The solenoid P is energized by interlock relay CR9 (heretofore described) and the normally closed contact of relay CR25. Thus, so long as relay CR25 is not energized, the solenoid P will be energized. The relay CR25 is responsive to relay CR40 (primarily responsive to relay CR17 which is energized upon movement of the parison mold segments). The normally closed contacts CR36 of relay CR40 are closed so long as the head is not in its up position through pressure switch PS9. The normally closed contacts of relay CR24 are open by movement of the core pin from its upper position as determined by limit switch LS11. Accordingly, the solenoid P will be energized so long as relay CR25 is not energized.

At the same time that the solenoid P is energized, the solenoid S is energized as long as limit switch 13 is closed (LS13 being opened when the cross head 250 is nearly down) and relay CR23 is energized, this relay CR23 being energized concurrently

with the solenoid P. The solenoid S shifts to the left pilot valve PV4 for the control valve V7, thus interconnecting fluid pressure line 400 by pilot valve passage PV4—1 to line 440 with control valve cylinder 441. In this manner, branch drain line 438 (joined to the drain lines 433 of the lower ends of the core cross head cylinders 252) is connected through control valve passage V7—1 and line 442 with the pressure supply line 432 for the upper ends of the core cylinders 252. Thus, drain fluid from the underside of the core pistons is recirculated through line 438, valve passage V7—1 and line 422 into the fluid pressure supply line 432 for the upper ends of the core pistons.

Thus, a rapid movement, regenerative, low pressure displacement of the pistons is ensured. By the simultaneous actuation of the solenoids P and S, simultaneous actuation of valves V6 and V7 is ensured.

Interposed in the path of movement of the core pin cross heads is the limit switch LS13. From Fig. 31 it will be seen that this limit switch is in the actuation circuit for the solenoid S and, upon opening of the limit switch, the solenoid S will be de-energized. De-energization of the solenoid S will return the pilot valve PV4 to its central position, the control valve V7 will be returned to its central position, and the undersurfaces of the core pin pistons will be vented to the sump S through the line 435 and the pressure regulator valve 436 as heretofore described. Thus, the full hydraulic pressure in the line 400 will be exerted upon the upper surfaces of the piston to firmly lock the core pin cross head in its down position.

The next successive step involves the downward displacement of the piston of the head cylinder 245. This head cylinder 245 is actuated by control valves V8 and V9 in combination. First, pilot valve PV5 for valve V8 is shifted to the right by energization of the solenoid T. Such energization of the solenoid T interconnects fluid pressure line 400 with cylinder line 444, i.e. by pilot valve passage PV5—1 to introduce fluid under pressure through pilot line 445 to actuate control valve cylinder 446, thereby shifting the control valve V8 to the right and connecting the line 400 directly to the cylinder line 444 by means of control valve passage V8—1.

By simultaneously actuating the solenoid W of pilot valve PV6, the pilot valve PV6 is displaced to the left, interconnecting the fluid source line 400 through pilot valve passage PV6—1 and pilot valve conduit 447 with control valve cylinder 448. Thus, the control valve V9 is displaced to connect line 444 through branch line 449 and control valve passage V9—1 and by line 451 to the drain line 450 leading to the underside of the head cylinder piston.

The same rapid traverse, low pressure, regenerative flow of hydraulic fluid is obtained by the combination of control valves V8 and V9 as heretofore described in connection with control valves V6 and V7. Essential to such flow is the relief valve 452 in the normal drain line 453 for the head cylinder piston underside. Even though the line 453 is connected by the control valve passage V8—2 with the sump through line 454, regenerative flow will occur at less than the pressure necessary to actuate the valve 452.

Solenoids T and W are connected generally in parallel as illustrated in Fig. 31 of the drawings. The energization of these solenoids T and W is dependent upon closure of the timer switch 1 and actuation of the four relays CR19 (responsive to closure of the parison molds 310 and actuation of pressure switch PS2), relay CR22 (responsive to clamping of the neck molds as indicated by actuation of pressure switch PS5), relay CR27 (responsive to clamping of the core pin as indicated by pressure switch PS6) and relay CR35 (responsive to the blow molds being open as indicated by limit switches LS9 and LS10, which are normally open switches, being closed by the blow molds assuming an opened position). Additionally interposed in the circuit of solenoid W is relay CR30 (energized when the solenoid T is energized) and limit switch LS14 (opened as the cross head approaches its lower or clamped position).

Upon opening of the limit switch LS14, solenoid W will be de-energized and the pilot valve PV6 will be actuated to the right, connecting the pilot valve cylinder 448 to drain, through line 455 and pilot valve passage PV6—3, thus centering the control valve V9 in its illustrated position and interrupting communication between the drain line 451 and the control valve passage V9—1. Accordingly, regenerative fluid flow between the two sides of the head cylinder pistons will be interrupted and continued downward travel of the head cylinder piston will be due to the flow of pressure fluid through the line 444 from valve V8 alone, the undersurface of the piston being connected to the sump S through lines 450 and 453, control valve passage V8—2 and line 454 when the pressure in the line 450 exceeds the pressure necessary to actuate the relief valve 452. Thus, the cross head will rapidly decelerate against the increased resistance on the underside of the cross head cylinder piston and the cross head will be finally clamped in its lowered position, to complete the injection mold, by the increased hydraulic pressure in the line 444.

At this time, the complete injection mold

is defined by the closing movement of the main cross head 243 by the core cross head 250, by the closed neck molds 241 and by the closed outer peripheral parison mold segments 310.

The next step in the operation involves the displacement of the plasticized material through the injection sleeve 161 by means of the injection ram 223 (Fig. 39). This ram 223 has its actuating piston enclosed within the cylinder 218 and is actuated to closed position by means of pilot valve PV7 controlling the operation of control valve V10. The solenoid S displaces the pilot valve PV7 to the right to connect line fluid pressure in conduit 400 through pilot valve passage PV7—1 and control valve conduit 455 with control valve piston 456, displacing the control valve to the left. Such displacement interconnects conduit 400 to control valve passage V10—1 with conduit 457 leading to the undersurface of the ram piston. The upper surface of the ram piston is connected to drain through conduit 458 and control valve passage V10—2.

The solenoid B is energized as illustrated in Fig. 31 of the drawings. More particularly, the solenoid B is energized by a timer contact TM1, relay CR28, (responsive to clamping of the cross head as indicated by pressure switch PS8) and relay CR8 (responsive to movement of the plastic valve to its closed position of Fig. 26 as indicated by limit switch LS6).

Since the clamping of the cross head 253 is the last operation necessary to complete formation of the closed injection mold, it will be appreciated that the injection piston or ram 223 is energized upwardly only after the complete injection mold has been formed. As the ram travels upwardly, it closes the injection mold and, when the final mold closing position is attained, limit switch LS1 is actuated. Actuation of limit switch LS1 makes the circuit for a timer TM1, as best shown in Fig. 30 through the initial timer contacts TM1, through relay CR28 (responsive to clamping of the head through pressure switch PS8) and relay CR19 (responsive to closure of the parison molds as indicated by pressure switch PS3). The initial timer contacts TM1 also make a circuit for a timer delay TD2 through the normally closed contacts of relay CR17, so long as the relay CR17 is not energized by opening of the parison molds as indicated by limit switches LS7 and LS8. The time delay contacts of relay TD2 in turn bridge the timer contacts TM1 so as to ensure timing out of the time delay TD2. When the timer TM1 times out, the solenoid B for pilot valve PV7 is de-energized and the pilot valve PV7 is centralized. The valve passage 455 is thne drained and the cylinder 456 for the control valve V10 allows centralizing of the valve body and both sides of the ram piston are connected to the sump S through control valve passage V10—3 and sump line 459. Thus, the injection force is removed from the injection ram 223.

After the release of the injection pressure, the main cross head 243 is released by deactivation of solenoid T and the resultant centering of the valve V8. As indicated in Fig. 31 of the drawings, this release occurs on the expiration of the timer and opening of the timer contact TM1 (CR34 being unactuated).

Next, the parison mold segments are retracted by the simultaneous actuation of solenoid J and deactuation of the solenoid K. Deactivation of the solenoid K and the activation of the solenoid J will shift the pilot valve PV2 to the right, thereby interconnecting fluid line 460 to the pressure fluid line 419 through valve passage PV2—2 and pressurizing the control valve cylinder 461. The control valve cylinder 461 displaces the valve body V5 to the right so as to connect fluid pressure line 418 to the line 421 through valve passage V5—4 and simultaneously connecting the cylinder pressure line 420 to the sump line 462 by the valve passage V5—5. Thus, fluid pressure within the lines 421 and 422 retracts the parison cylinder pistons, opening the parison molds upon actuation of the solenoid J.

Referring to Fig. 30, it will be seen that solenoid K is de-energized after the delay for the opening of contact TD2 in series with it. It will be noted that the contact TM1 in series with coil TD2 is a holding subcircuit with normally open contact TD2 of the delay solenoid TD2, so that the solenoid K remains de-energized until coil TD2 of the timer TD2 is deenergized even though the coil TM1 has been deenergized to open the contact TM1. The limit switch LS7, by prior actuation of the parison molds toward their closed position results in the closing of a normally closed contact in series with the solenoid J; the closing of the contact TD2 after its delay will actuate the solenoid J. It will be noted that relay CR16 is actuated at the same time as the solenoid J and its holding contact is in parallel with the time delay contact TD2. Thus, the solenoid J will remain energized until the parison molds are completely open and the limit switch LS7 is tripped to open the normally closed contact LS7.

After opening of the parison molds, the injection ram 223 is retracted downwardly by actuation of the solenoid A. As previously explained, the solenoid B had been previously deactivated. Actuation of the solenoid A moves the pilot valve PV7 to the right introducing pressure fluid from the line 400 through the line 464 into the cylinder 465 of the control valve V10, shift-

ing the control valve to the right to interconnect the pressure line 400 and the conduit 458 leading to the upper end of the ram cylinder through pilot valve passage V10—4. Pilot valve V10—5 connects the lower conduit 457 of the cylinder to the drain line 459.

Actuation of the solenoid A is accomplished, as illustrated in Fig. 31 by a circuit established through relay CR17 (energized upon opening of the parison mold segments for the closure of the normally open contact of the limit switch LS7 and the normally open switch LS8), relay 24 (primarily responsive to relay CR26 so long as the core pin is down and pressure switch PS7 is not closed) and the normally closed contacts of relay CR37 (i.e. so long as the ram is not in its down position to close the normally open limit switch LS3).

Thus, opening of the parison molds and actuation of the relay CR17 will actuate the solenoid A to retract the piston to its fully down position. Once this fully down position is attained and limit switch LS3 is closed to energize coil CR37 of relay CR37, the contact CR37 opens to de-energize the solenoid A. The ram will remain in its lower position by centering of the pilot valve PV7 and the control valve V10 with the control valve passage V10—3 connecting both ends of the cylinder to the drain line 459.

At the same time that the opening of the parison molds actuates solenoid A, by relay CR17, the solenoids U and V are energized (Fig. 31). Actuation of these solenoids U and V is effective to displace the pilot valves PV5 and PV6, respectively, since the previous opening of the time opening timer contact TM1 deenergized the solenoids T and W. The actuation of solenoid U will shift the pilot valve PV5 to the left (Fig. 40) so that pilot valve passage PV5—2 connects the fluid pressure line 400 with passage 466 to actuate control valve cylinder 467, shifting the control valve V8 to the left and interconnecting lines 400 and 453 through line V8—3. At the same time, valve passage V8—4 interconnects line 444 with drain line 454. Thus, fluid flow occurs into the bottom of the cross head cylinder 245 through line 453 and through the check valve portion of the pressure relief valve 452.

The simultaneous energization of solenoid V shifts the pilot valve PV6 to the right, so as to connect the fluid supply line 400 through line 468 and valve passage PV6—2 with the actuating cylinder 469 of the control valve V9. The resulting shift to the right of the control valve V9 will connect the top line 444 of the cylinder 245 with the drain through conduit 455 and control valve passage V9—2. Thus, the head cylinder 245 will be effective to elevate the head and to maintain the head elevated so long as the parison molds are open and the normally opened limit switches 7 and 8 are closed to keep the relay CR17 actuated.

The core cross head cylinders 252 are actuated upwardly at an initial flow rate by actuation of the solenoid Q. Referring to Fig. 31 of the drawings, it will be seen that this solenoid Q is actuated primarily by relay CR40 (actuated by relay CR17 simultaneously with the solenoids A, U and V as heretofore described) and also by the normally closed contacts of the relays CR36 (closed since the head is not up and normally open pressure switch PS9 is not closed), relay CR24 (closed since the limit switch LS11 is not closed until the core pin is substantially in its elevated position) and relay CR9.

As will be readily seen from Fig. 40, actuation of the solenoid Q will shift the pilot valve PV3 to the left, the other actuating solenoid, solenoid P for the pilot valve PV3 being previously deactivated by actuation of the relay CR25 (made at the same time as solenoid Q is energized). Thus, the pilot valve passage PV3—2 interconnects the fluid pressure line 400 with conduit 470 energizing the control valve cylinder 471 so that control valve passage V6—3 can interconnect the line 400 with the conduits 437, 435 and 433 leading to the undersurface of the core pin cylinder pistons through the check valve of relief valve 436. At the same time, the conduit 432 is vented to the sump through control valve passage V6—4 and conduit 472. Thus, the core cross head cylinders 252 are actuated to retract the pistons therein and to move the cross head 250 upwardly.

As the core pin pistons move upwardly, the normally open limit switch LS12 is closed for a brief time and since relay CR25 has already been energized, solenoid R is energized to shift the pilot valve PV4 to the right (Fig. 40), such shifting of the pilot valve PV4 positions valve passage PV4—2 to connect the fluid supply line 400 with passage 473 so as to actuate cylinder 474 of the control valve V7. The consequent shift to the right of the control valve V7 positions valve passage V7—2 to additionally drain line 432 to the sump through line 422 and sump conduit 475. By opening the drain line in this manner, it is no longer necessary for fluid passing through the line 432 to drain through the restricted orifice 476 interposed therein and rapid upward movement of the core pin cylinder pistons is facilitated.

To decelerate the cross head 250, the limit switch LS12 is opened to de-energize solenoid R, as above explained. Next, the switch LS11 is tripped closed to de-energize

solenoid Q, by energizing relay CR24, centering the valve V6 by pilot valve PV3.

The movement of the main cross head 243 and of the core cross head 250 upwardly positions the completely formed and partially stripped preform 120 in horizontal alignment with the blow molds. The next step involves the closure of the blow molds, this step being performed by actuation of the solenoid G.

As can best be seen from Fig. 39 of the drawings, actuation of the solenoid G will shift the pilot valve PV1 to the right, since the solenoid H has been previously de-energized by opening of the parison molds, opening limit switch LS7 in the circuit for relay CR16. Further, the relay CR15 has been previously de-energized by expiration of the time determined by the timer delay relay TD2.

Energization of the solenoid G is accomplished upon movement of the cross head 243 to its upper position closing pressure switch PS9 and energizing relay CR36, the relay CR22 remaining energized by the neck clamp pressure switch PS5. This energization of the solenoid G will shift the pilot valve PV1 to the right, so as to interconnect the pressure line 400 with valve conduit 477 through valve passage PV1—2. As a consequence, the valve cylinder 478 will shift the control valve V4 to the right, connecting pressure line 400 through valve passage V4—2 to conduit 479.

The control valve V11 is in its neutral illustrated position of Fig. 39 and pressure from conduit 479 will flow through the valve passages V11—1 and V11—2 into conduit 480 to the rear side of the blow mold cylinders to displace the blow mold segments inwardly toward one another. Fluid, not under pressure, from the inner ends of the blow mold cylinders is conducted through line 481 and valve passage V11—1 into the valve passage V11—2 for merging with the pressure fluid flowing therethrough. Thus, the recirculated fluid will exert a high speed, low force, regenerative displacement of the blow mold sections.

It will be noted from Fig. 31 that the actuation of solenoid G will not actuate solenoid M so long as the normally closed contacts of relay CR34 are open (i.e. so long as CR34 is actuated). The actuation of solenoid CR34 is in response primarily to the pressure switch PS11 which is, in turn, responsive to blow air. When the blow air is off, pressure switch 11 is closed and relay CR34 is energized. When the blow air is on the switch PS11 is open and relay CR34 is not energized. Relay CR34 also requires for its energization non-actuation of the relay 39 (responsive to opening of the blow molds as determined by limit switches LS9 and LS10). Thus, relay CR34 is not actuated and solenoid M is actuated when the blow air is on.

Thus, the correlation of solenoids G and M is such that solenoid G rapidly actuates the blow molds to their closed position and once PS4 is closed the blow air comes on and solenoid M is energized to clamp the blow molds shut by interrupting the low force, rapid traverse movement of the blow mold cylinders. More specifically, energization of the solenoid M will move the pilot valve PV8 to the left to interconnect the pressure line 482 with the valve passage PV8—1, thus energizing valve cylinder 483 to shift the control valve V11 to the left.

This leftward displacement of the valve V11 connects the line 479 with the line 480 by means of valve passage V11—3. At the same time, valve passage V11—4 connects the forward end of the blow mold cylinders, by line 481, with the sump by line 484, thus ensuring full line pressure within the blow mold cylinders urging the blow mold segments to their closed mold-defining positions.

As illustrated in Fig. 41 of the drawings, air at appreciable pressure, preferably on the order of one hundred pounds per sq. inch is supplied through line 500. This air is supplied through line 501 and branch lines 503 to the plurality of pressure switches PS1 to PS9 as heretofore described. Pressure to the pressure switches is substantially less than the pressure in the source line 500 as determined by a pressure regulator 502. Pressure in the line 500 is also supplied through a pair of air control valves 504 and 505 to the core passages 302 heretofore described, as through conduit 301. Disposed in this conduit is a pressure switch PS11 indicating the presence of blow air at full blowing pressure (i.e. about 100 p.s.i.) in the line 301.

The air control valve 504 is provided with a passage 506 by means of which air is supplied through a regulator line 507 and a pressure regulator 508 to a variable orifice 509 to provide regulated low pressure air in line 510. This regulated low pressure air is under the control of the air control valve 504.

Solenoid X is provided to actuate the valve 505 from its illustrated position in which air is vented through a valve exhaust passage 511. Upon actuation of the solenoid X, the valve 505 is shifted upwardly so as to interconnect the lines 510 and 301 by means of the valve passage 512, thereby introducing air at regulated lower pressure into the line 301.

To introduce high pressure air into the line 301, the valve 504 is actuated by the solenoid Y to shift the valve 504 upwardly thus interconnecting the supply or high pressure line 500 by valve passage 514 with

a by-pass line 515 extending around the pressure regulator 508 and the orifice 509 but communicating with the line 301 through the valve passage 512 of the valve 505 and the line 510. It will be noted that the low pressure line 507 and the high pressure line 515 are provided with check valves 516, respectively, to prevent back flow of pressure therethrough.

As above explained, the low pressure air is introduced into the line 301 by actuation of the solenoid X, so long as the solenoid Y is not energized. Energization of the solenoid X, according to Fig. 43 of the drawings, requires completion of the injection molding operation (by non-energization of the relay CR29 when the timer relay TM2 has timed out), clamping of the core pin in its down position (by relay CR27 responsive to actuation of pressure switch PS6), opening of the parison molds (by relay CR17 responsive to limit switches 7 and 8 by relay CR25 dependent upon relay CR40 depending in turn upon relay CR17), and the positioning of the blow molds in their open positions. Thus, low pressure air is introduced into the injection molded parison to expand the parison and aid in stripping the parison from the core sleeve 275 upon initial movement of the sleeve and prior to appreciable movement of the core sleeve upwardly. Such upward movement of the core sleeve will not disturb actuation of the solenoid X, as prior actuation of the relay CR33 parallel therewith will by-pass the contacts of CR27. Upon the closing of the pressure switch PS4, retraction of the core pin upwardly to its intermediate position contacting limit switch 11 (as determined by relay CR24) but not to such an extent as to actuate pressure switch PS7 (at which the core pin is completely up and relay CR26 is actuated) and so long as the interlock relay CR9 is not actuated, solenoid Y will be energized to introduce full pressure blow air into the preform 120 as enclosed by the blow molds and clamped therein by the simultaneous actuation of the solenoids G and M as heretofore described. The energization of the solenoid Y and of the solenoid X ceases when contact TM2 of the delay-closing type closes to energize the relay CR29 to open normally closed contacts CR29 in series with these solenoids. During the blowing operation, the plastic valve is in its open position so that the accumulator is filled with plasticized material for the next subsequent operation.

Following the blowing operation, the blow molds are opened by actuation of the solenoid L of the pilot valve PV8. When the blow air is shut off by closure of the solenoids X and Y as heretofore described, the pressure switch PS11 closes and the relay CR34 is energized simultaneously with the solenoid L. Energization of the relay CR34 simultaneously breaks the circuit for the solenoid M without disturbing the solenoid G. Thus, valve V4 remains in its heretofore described right-hand position, while the energization of the solenoid L shifts the pilot valve PV8 to the right, so that the valve passage PV8—2 interconnects the pressure fluid line 479 and valve conduit 490 actuating valve cylinder 491 to displace the control valve V11 to the right. In this position, the valve passage V11—5 interconnects the pressure line 481 and the line 479 to introduce fluid under pressure into the inner ends of the blow mold cylinders, thereby retracting the cylinder pistons and opening the blow mold segments. Drain fluid from the outer ends of the blow mold cylinders is drained through line 480 and valve passage V11—6 through the sump line 484.

Following opening of the blow molds, the core cross head 250 is moved upwardly by the core cylinders 252 to strip the neck sleeve 287 by the pins 298. More specifically, the solenoid Q is energized to connect the hydraulic pressure line 400 by valve passage PV303 with valve conduit 403 to actuate the control valve cylinder 471, displacing the control valve V6 to the left, as heretofore described.

This actuation of the solenoid Q has been heretofore described and is interrupted by the solenoid Q being de-energized upon actuation of the relay CR26 upon closure of the pressure switch PS7 (indicative of full upward retraction of the core cross head).

The final step in the operation is the opening of the neck molds 241 by actuation of the cylinders 238. This is accomplished by energizing the solenoid M to displace the control valve V3 to the right to connect the inner ends of the neck cylinders 238 by conduit 411 and valve passage V3—3 with the fluid pressure line 400. Simultaneously valve passage V3—4 connects the rear ends of the cylinders to the sump S through line 410.

Energization of the solenoid N is accomplished primarily by actuation of the relay CR26 in response to full upward movement of the core cross head to close pressure switch PS7. The solenoid O is de-energized simultaneously by actuation of the relay CR21, and the opening of the normally closed contacts thereof in circuit with the relay CR20.

Opening of the neck rings releases the part for removal manually or by any desired take-out mechanism. The machine is now conditioned for a repeat of the cycle heretofore described.

SUMMARY

From the foregoing description of the

several embodiments of applicant's invention, it will be seen that the apparatus utilized is capable of substantial variation but that, in each instance, the formation of the preform is carried out by an injection molding procedure wherein the plasticized material from which the preform is to be made is completely confined at all its dimensions and is subjected to the substantial molding pressures developed by an injection piston. At the same time, the completely confined and injection molded preform is made without the necessity of forcing material through extremely restricted orifices and without the formation of minute joining portions or webs surrounded by massive heat extraction surfaces. In other words, the injection molding step of the process is carried out without introducing into the injection molded preform those structural and/or thermal weaknesses inherent in all previously utilized injection molding processes.

By thus injection molding the preform in a mold wherein substantially one entire transverse dimension thereof is utilized for the introduction of material into the injection mold and upon which the injection molding pressure is applied over a substantial area of the injection molded preform, a preform of improved structural and thermal characteristics is obtained. These characteristics of the preform are utilized to excellent effect during a subsequent blowing operation inasmuch as the preform will not "blow out", even upon the subjection of the preform to blowing pressures of one hundred pounds per square inch or greater, and the rapid blowing at such high pressures is rendered effective for the first time as applied to an injection molded preform.

By utilizing the comparatively large area piston or injection ram and injection molding at comparatively low pressures, another disadvantage of the normal high pressure injection molding technique is avoided. As the plasticized material cools in the injection mold, thermal shrinkage occurs and high pressure injection compacts the solidifying material as such shrinkage occurs. By the use of low pressures, as herein proposed, such compaction is avoided and a material saving of about 5% of the article weight is obtained.

Further, and even more importantly, this improved injection molded preform, and its highly desirable and novel characteristics, is evident in the final blown article inasmuch as the finished article can be only as good as the preform from which it is made. By such injection molding, complicated preforms of tapered configuration, of substantially differing wall thicknesses and of widely variant shape can be injection molded, whereas such preforms could not be extruded. Further, the final article possesses the full isotropic characteristics of the plastic material from which it is formed, and the final article is free of structural weaknesses and thermally induced stress concentrations. The resultant vastly improved articles could not be obtained by any previously known or conventional process for injection moulding a preform.

Therefore, an important advantage of the present invention lies in a novel method of making a blown plastic article by the blow moulding of an injection moulded blank free of waste and free from structural defects caused by earlier proposed injection moulding techniques.

Another important advantage of this invention lies in the provision of an improved blow moulded plastic article possessing the full isotropic properties of the plastic material and free of thermally induced structural defects.

A further advantage of this invention lies in an improved method for the manufacture of a plastic article by injection moulding a blank or preform in an injection mould cavity substantially one dimension of which is defined by a pressure-producing element, removing the preform from the injection mould cavity and promptly blowing the preform without reheating to a final configuration conforming to that of an enclosing blow mould.

Yet another important advantage of this invention lies in the provision of the method of making a plastic article by providing an injection mould cavity having one open side, simultaneously filling the injection mould cavity with plasticized material through the open side of the mould, closing the open side of the mould to subject the plasticized material to injection moulding pressures, and then removing the injection moulded blank from the cavity and promptly inflating the same to its final configuration.

Still a further advantage of this invention lies in the provision of a plastic article which is blown to its final configuration without the formation of integral flash or waste portions and which is uniformly free of structural defects and of thermally induced stress concentration areas.

In co-pending Divisional Application No. 20119/64 there is disclosed a method of metering and dispensing through an outlet plasticized material which has been accumulated in a separate chamber fed by a plasticizer producing a constant output pressure, in which communication between the accumulator chamber and the plasticizer is blocked after a predetermined volume of plasticized material has flowed into the chamber under the output pressure from the plasticizer and the material in the chamber is then stored under a constant pressure different from and

less than said plasticizer output pressure, a predetermined portion of the accumulated volume of material being thereafter ejected under said different pressure in one operation from the chamber for dispensing through said outlet, and the chamber refilled with plasticized material to the same predetermined volume after said portion has been ejected.

Co-pending Divisional Application Serial 1,024,133, No. 20119/64 also discloses an apparatus for carrying out the above method which comprises a plasticizer producing a constant output pressure and having means of communication with an accumulator chamber, a piston reciprocable within said accumulator chamber to vary the volume therein, means for exerting a constant pressure against said piston in the direction of moving the piston into said chamber, said constant pressure being less than said plasticizer output pressure, valve means interposed between said chamber and plasticizer and between said chamber and outlet, respectively, and valve actuating means to place said valve means in separate positions for (1) interconnecting said plasticizer and said chamber to fill the chamber with plasticed material, (2) isolating said chamber from both said plasticizer and said outlet, and, (3) interconnecting said chamber and said outlet.

Attention is directed to the fact that Application No. 20119/64 claims subject matter forming part of the present description.

WHAT WE CLAIM IS:—

1. A method of forming a hollow plastic article by introducing internal fluid pressure into a hollow plastic blank, which is produced by pressure moulding plasticized material within an injection mould, and expanding the blank into the form of the finished article, in which one end of the injection mould, across which is formed one wall of the finished blank, is open and the perimeter of this open mould end extends away from the mould cavity as a passage, and said pressure moulding comprises the steps of depositing a measured charge of plasticized material in said passage, transferring the deposited charge along the passage into the injection mould cavity, and concurrently closing the open mould end and applying pressure to the plasticized charge within the closed mould cavity by advancing a piston along the passage as far as the volume of plasticized material in the mould cavity will permit.

2. A method as claimed in claim 1, in which said pressure moulded blank is removed from the injection mould for expansion by opening one end of the mould and moving the blank axially relative to the mould.

3. A method as claimed in claim 2, wherein said injection mould includes a separable neck mould superimposed over one of two open ends of the injection mould and a central mandrel projects through the neck mould into the injection mould, in which said piston is moved into the other of the open ends of the injection mould to close the mould and define a wall of the blank in the space between the mandrel and the piston in its forward position, and said blank is removed from the injection mould by concurrently moving the blank and neck mould axially relative to the injection mould.

4. A method as claimed in claim 3, in which the mandrel is moved concurrently with said blank and said neck mould in removing the blank from the injection mould.

5. A method as claimed in claim 4, in which fluid pressure is introduced into said blank through a passage within said mandrel.

6. A method as claimed in any of claims 1—5, in which said blank is enclosed within a blow mould where it is expanded into contact with the walls of the blow mould cavity.

7. A method as claimed in claim 6, in which a portion only of said blank is enclosed within the blow mould.

8. A method as claimed in claims 3 and 7, in which said portion of the blank enclosed in the blow mould is that portion of the blank outside the neck mould.

9. A method as claimed in any of claims 1—8, in which said measured charge is deposited into the passage by ejecting from a separate accumulation chamber a predetermined portion of a volume of material which has been plasticized in a plasticizer and stored under pressure in the chamber and said accumulation chamber is refilled to a predetermined volume each time said portion is ejected.

10. A method as claimed in claim 9, in which said predetermined portion is ejected from the accumulation chamber into said passage via a supply conduit, and said supply conduit is isolated from the accumulation chamber after said predetermined portion has been ejected.

11. A method as claimed in claim 10, characterized in that said isolated supply conduit is purged of the plasticized material contained therein prior to said accumulation chamber being refilled.

12. A method as claimed in claim 1 or 2, in which said injection mould has one section in which a neck portion of said blank is formed, another section in which the expandable portion of said blank is formed and a centrally located sleeve about

which the entire blank is formed, and said sleeve is withdrawn from within the expandable blank portion prior to expanding said blank which is supported at the neck portion by the sleeve while being expanded.

13. A method as claimed in claim 12, in which said blank is stripped, from the expandable blank forming section of the mould prior to being expanded, by concurrent movement of the piston and the neck mould section.

14. A method as claimed in claim 13, in which a valve closing that end of said sleeve which is within the mould is held stationary while said sleeve is withdrawn, whereby the blank is supported at the bottom by said valve and at the neck portion by said sleeve, and said valve is moved concurrently with said piston and neck mould section while stripping said blank from the expandable blank forming section of the mould.

15. An apparatus for carrying out the method as claimed in any of claims 1—14, comprising a main injection mould open at the top and bottom ends, a separable annular neck mould extending across and closing the top end of said main mould, a mandrel extending through said neck mould into the main mould as a central core, a piston spanning the bottom open end of said main mould and reciprocable therein from a retracted position to an extended position spaced closely to the bottom end of said mandrel to define a closed mould cavity in the space between the neck mould, main mould, mandrel and piston face, means for discharging a measured amount of plasticized material through a port connected to the bottom open end of said main mould between the forward and retracted positions of said piston to provide a charge of plastic material to form the hollow blank, pressure applying means for moving the piston from its retraction position as far forward toward the end of the mandrel as the volume of charge within the mould cavity will permit, and means for moving said neck mould and blank formed therewith axially away from said main mould and transferring them to an enclosing blow mould in which the blank is expanded.

16. An apparatus as claimed in claim 15, in which said mandrel has an internal passage exiting at the lower end of said mandrel which extends into the main mould and connected at the other end to a pressure source, said mandrel being movable with said neck mould and accompanying the moulded blank to the blow mould to provide a source of pressure to expand the blank within the blow mould.

17. An apparatus as claimed in claim 15 or 16, in which said means for discharging a measured amount of plasticized material includes an accumulation chamber having separate connections to a plasticizer and said port leading to the bottom open end of said main injection mould, a piston reciprocable within said chamber to vary the volume therewithin, pressure means for exerting a constant force against said accumulation chamber piston to force it into said chamber, valve means interposable between said chamber and plasticizer and between said chamber and port, and valve actuating means responsive to the position of said accumulation chamber piston to place said valve means in separate positions for (1) interconnecting said plasticizer and said chamber to fill the chamber with plasticized material, (2) isolating said chamber from both said plasticizer and said port, and (3) interconnecting said chamber and said port whereby the material within the chamber is forced by said pressure means through said port.

18. A hollow plastic article formed by the method as claimed in any of claims 1—14.

19. An article as claimed in claim 18, in which said expanded article and said blank from which it is formed are free of flash, waste, or excess material.

20. Methods of forming plastic articles substantially as herein described with reference to the accompanying drawings.

21. Apparatus for forming plastic articles substantially as herein described with reference to and as illustrated in the various embodiments of the accompanying drawings.

22. A plastic article when formed by the apparatus of any of claims 15—17, and 21.

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Liverpool 1.

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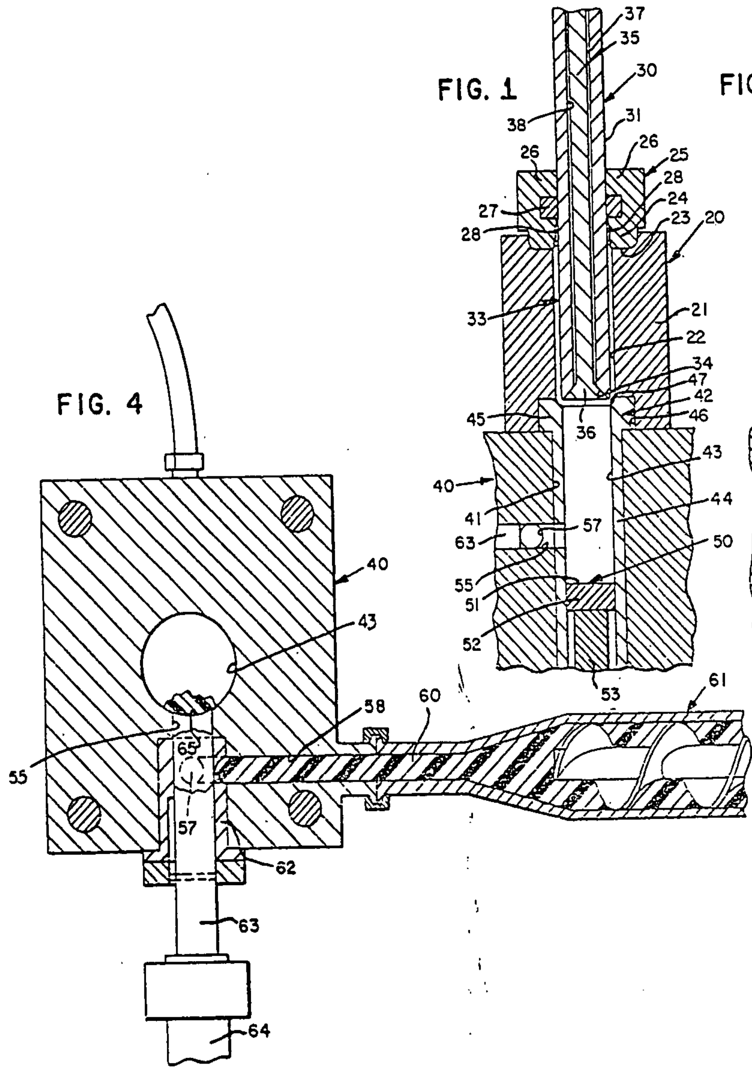
1024132 COMPLETE SPECIFICATION

14 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

FIG. 1

FIG. 4



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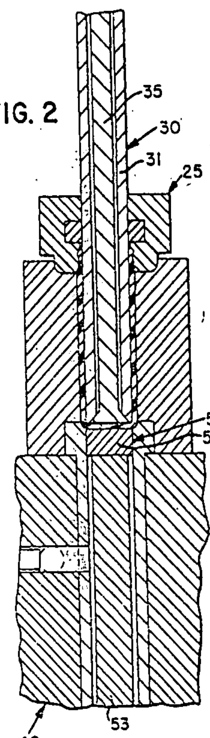

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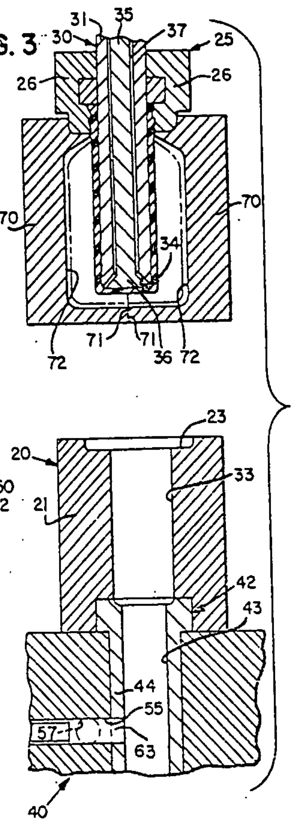

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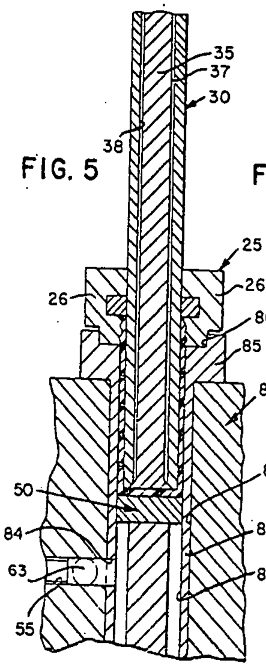
FIG. 5



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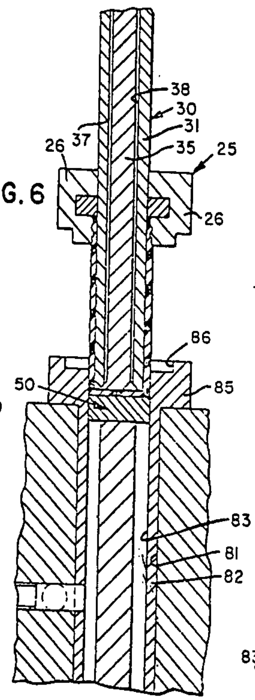

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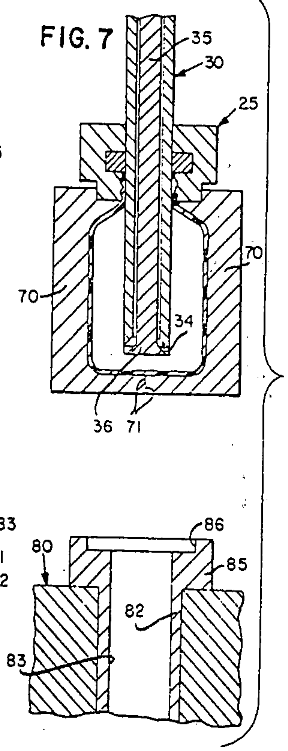

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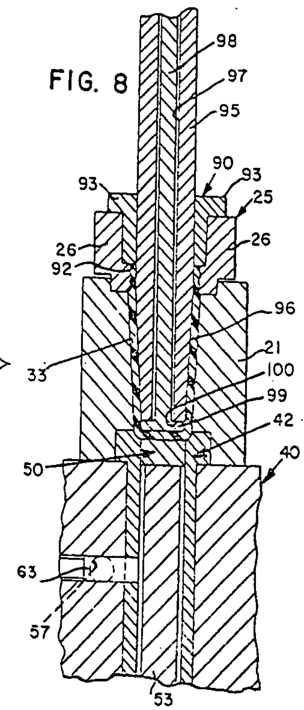

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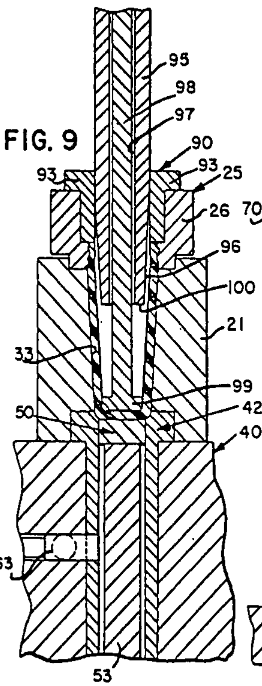

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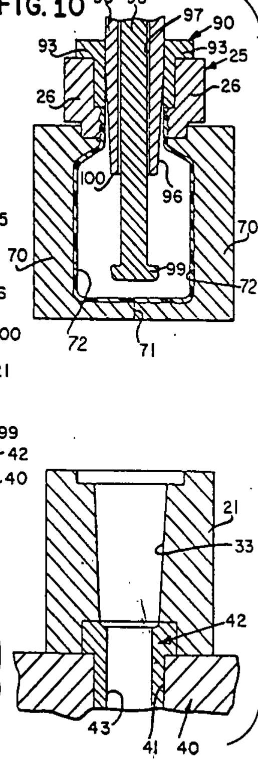

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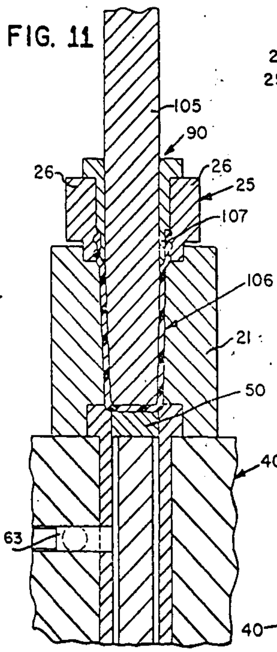

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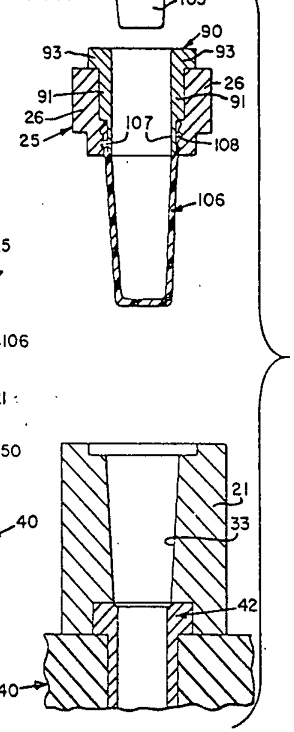

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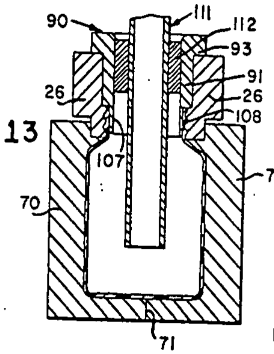

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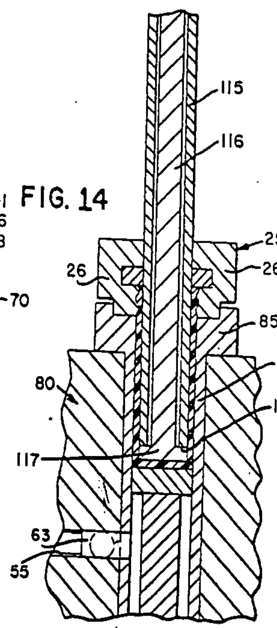

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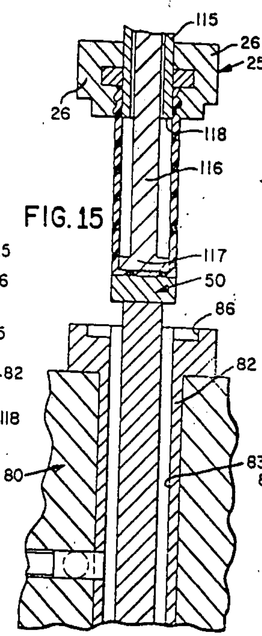
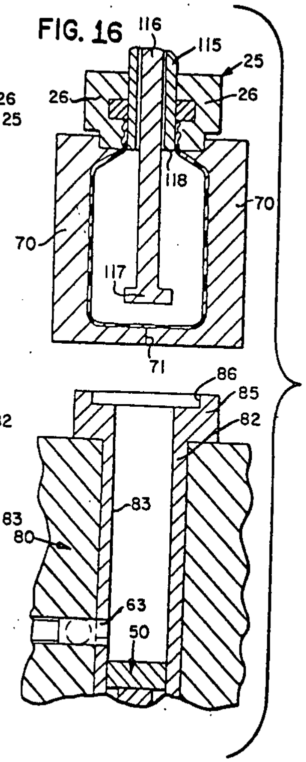


FIG. 16

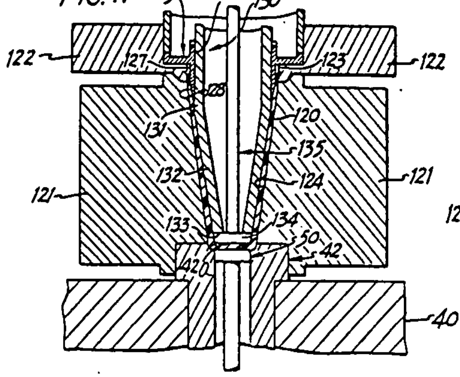


1024132 COMPLETE SPECIFICATION

14 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 5

FIG. 17



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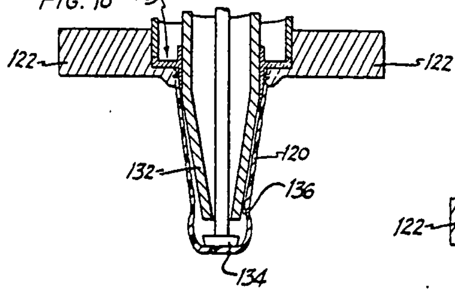

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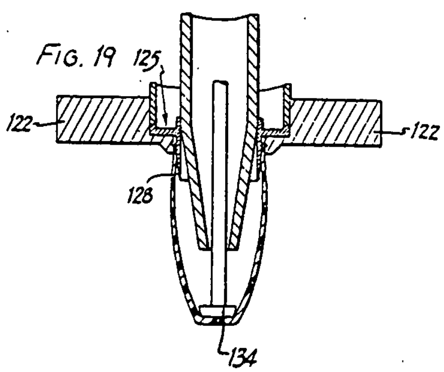
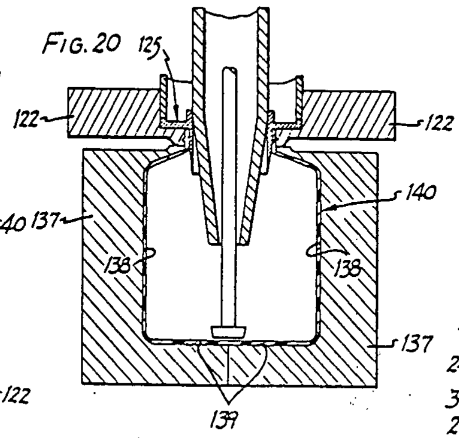


FIG. 20



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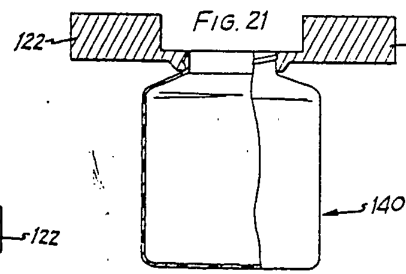

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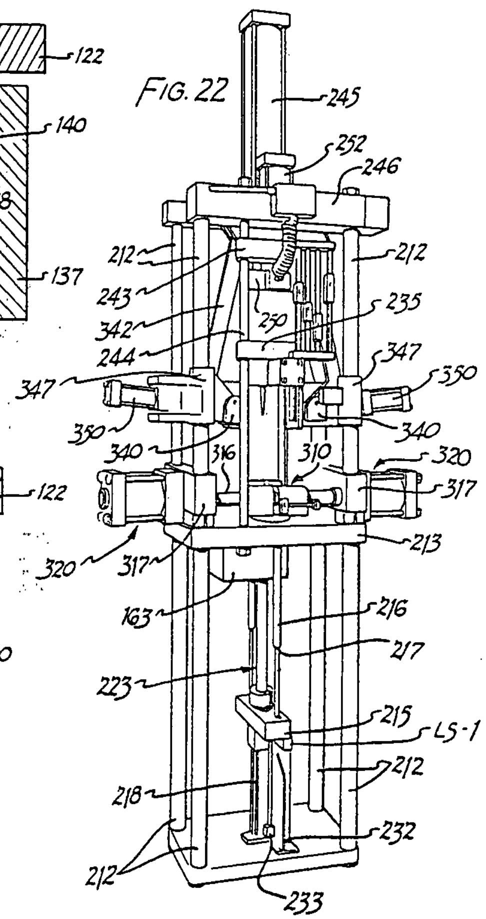

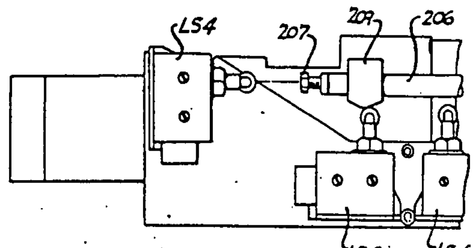

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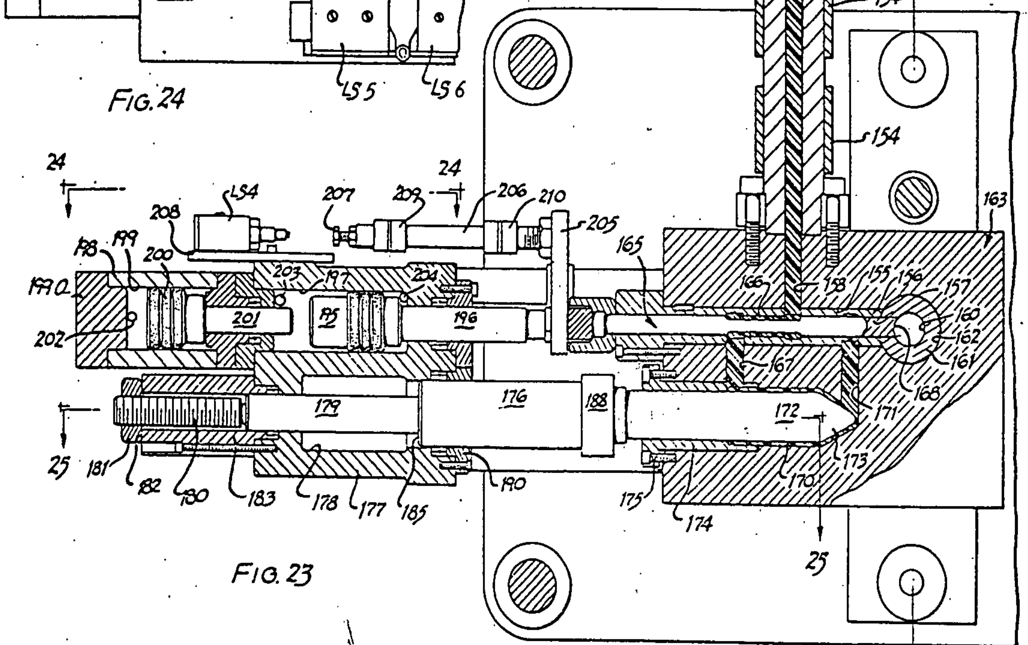

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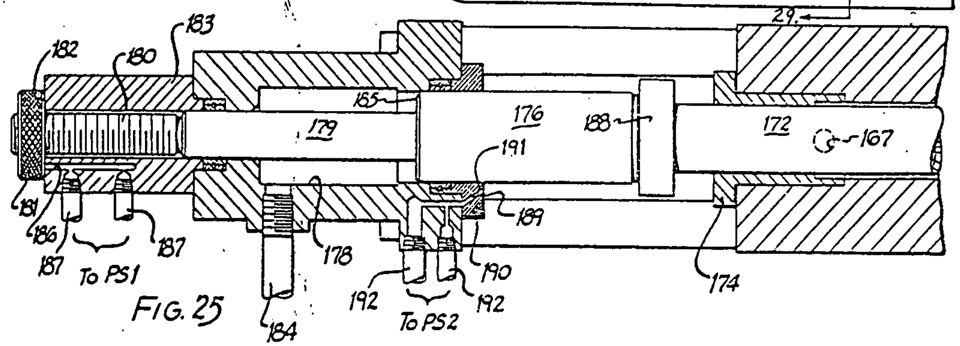

FIG. 25

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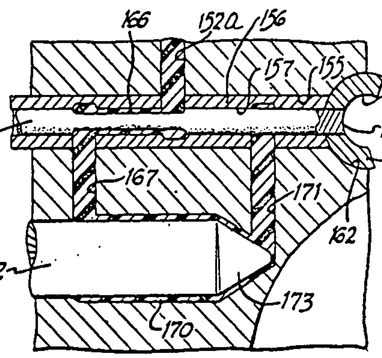
FIG. 26



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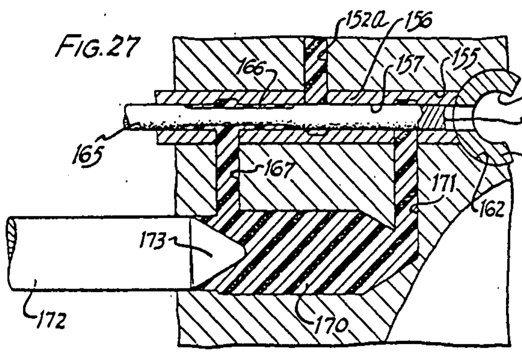

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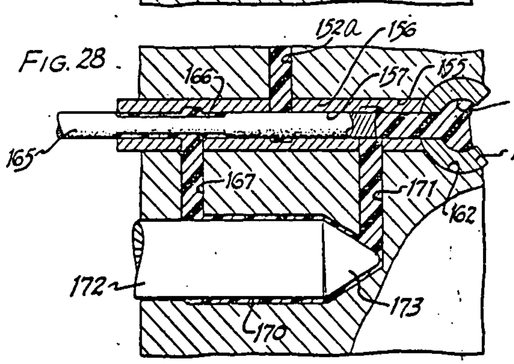

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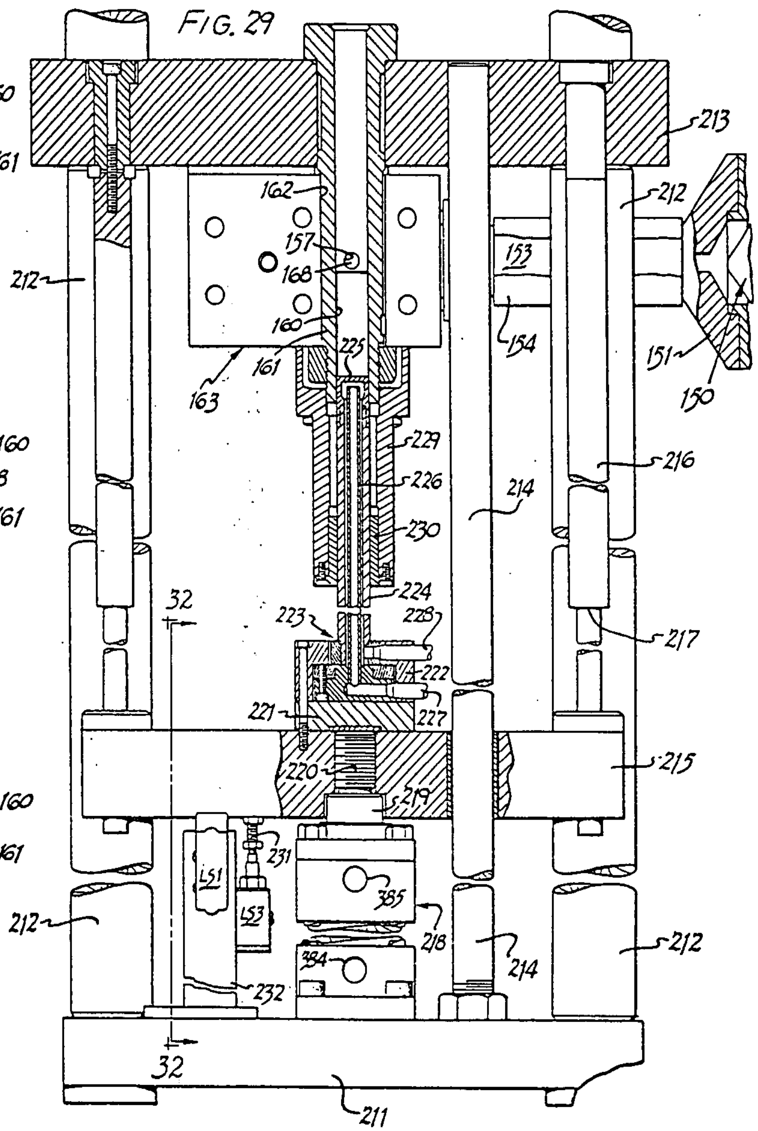

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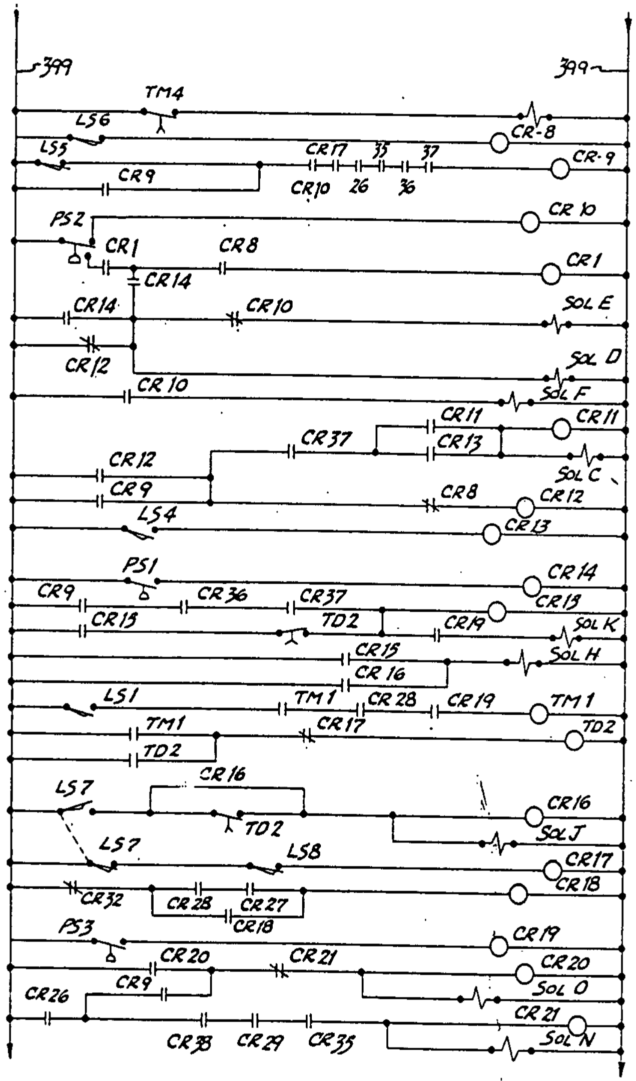

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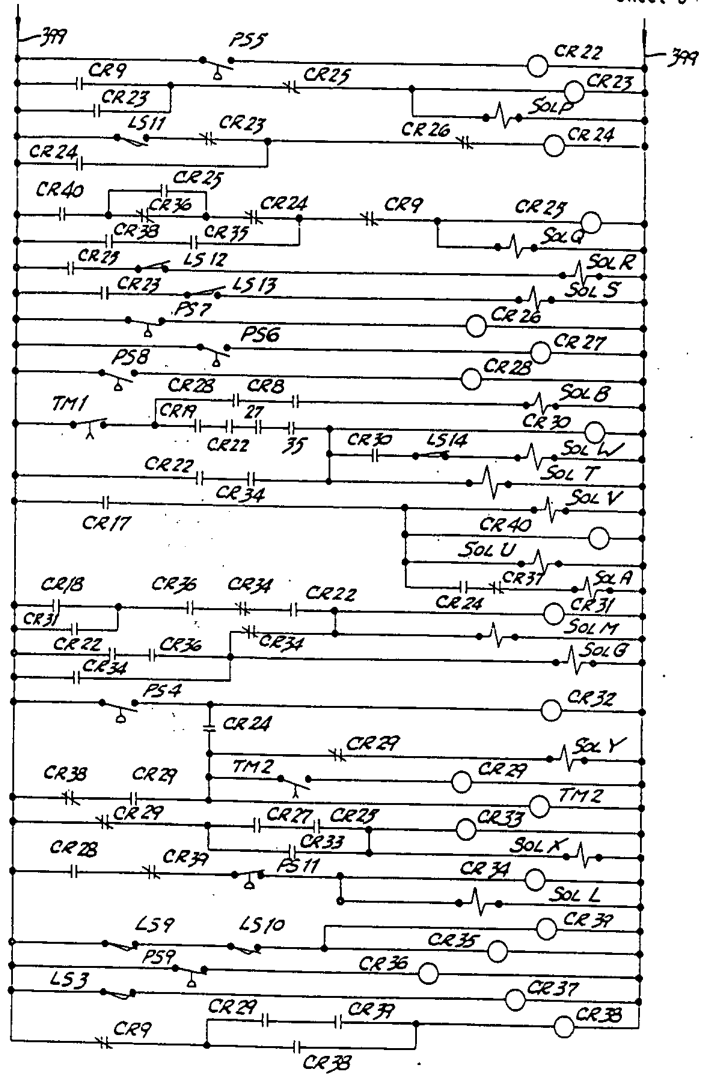

FIG. 31

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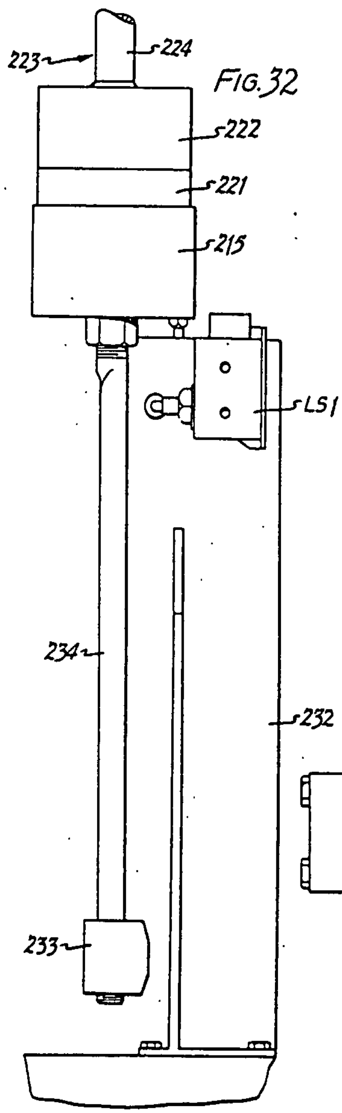
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FIG. 32

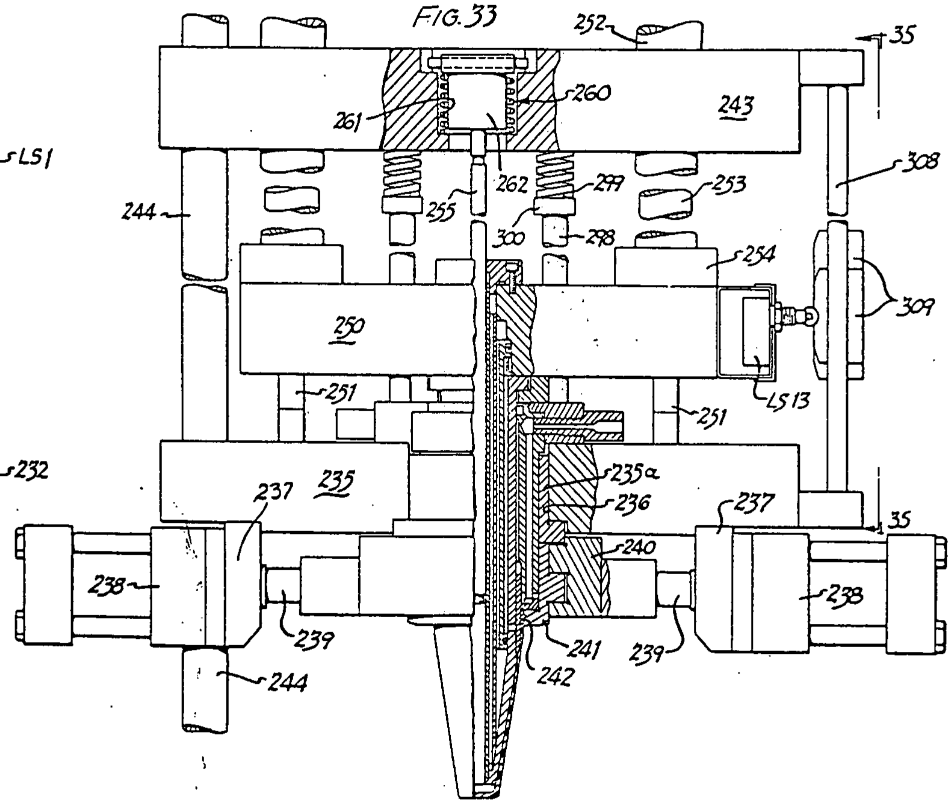
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FIG. 33

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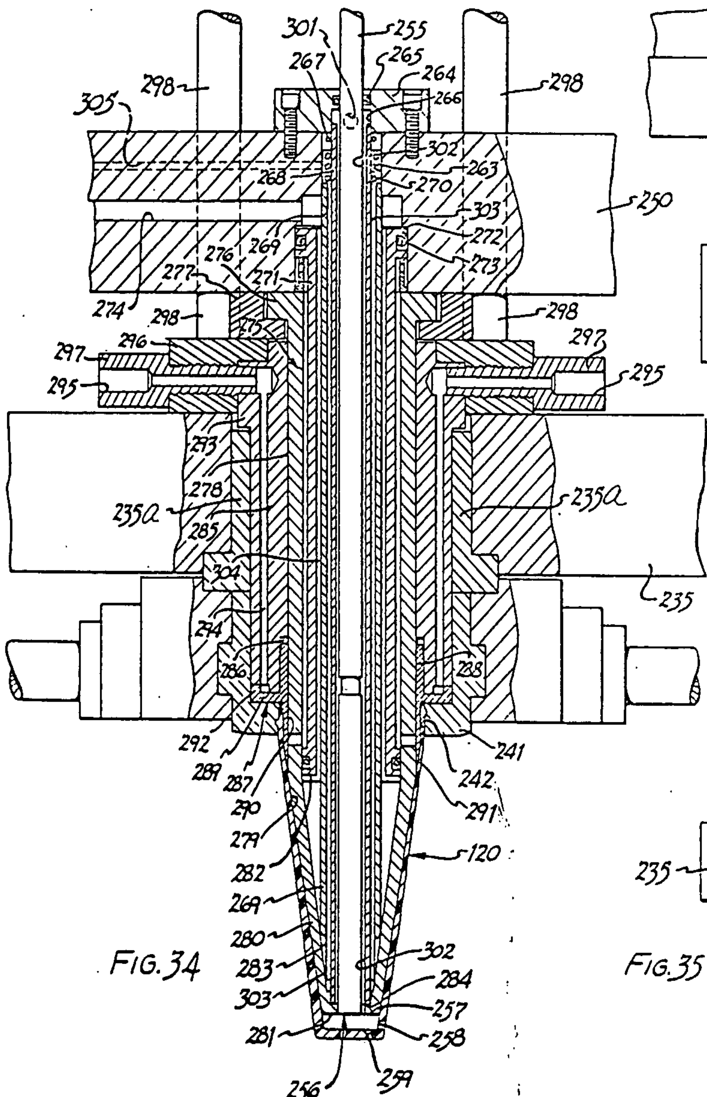
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FIG. 34

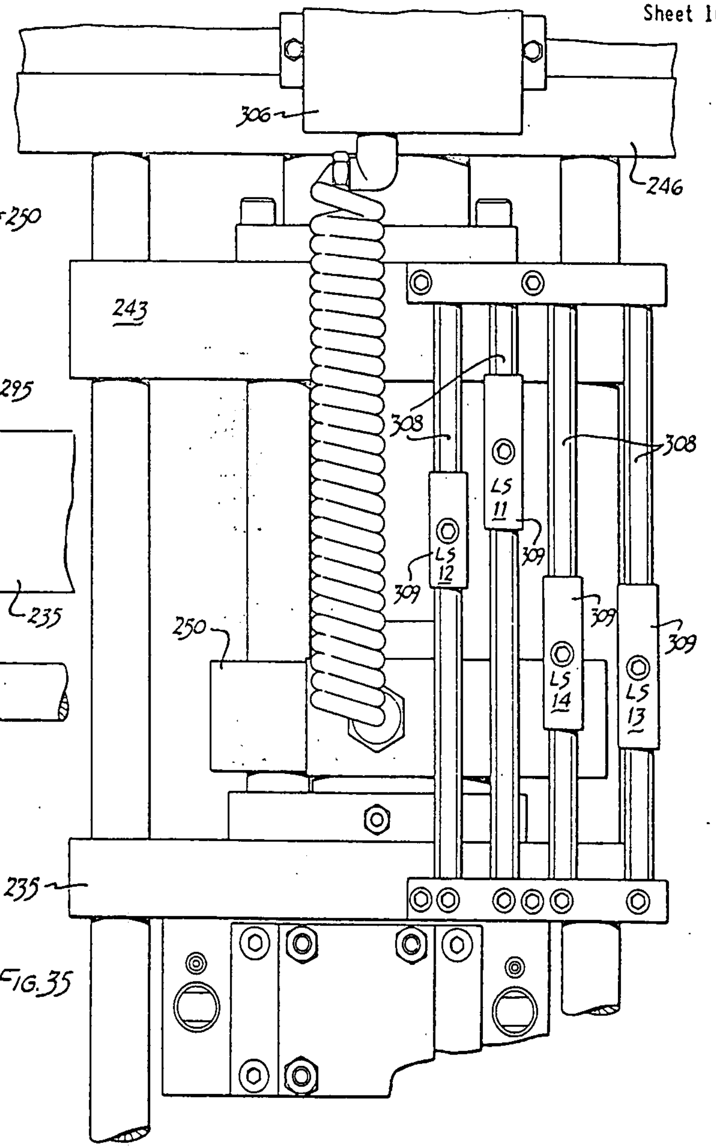
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FIG. 35

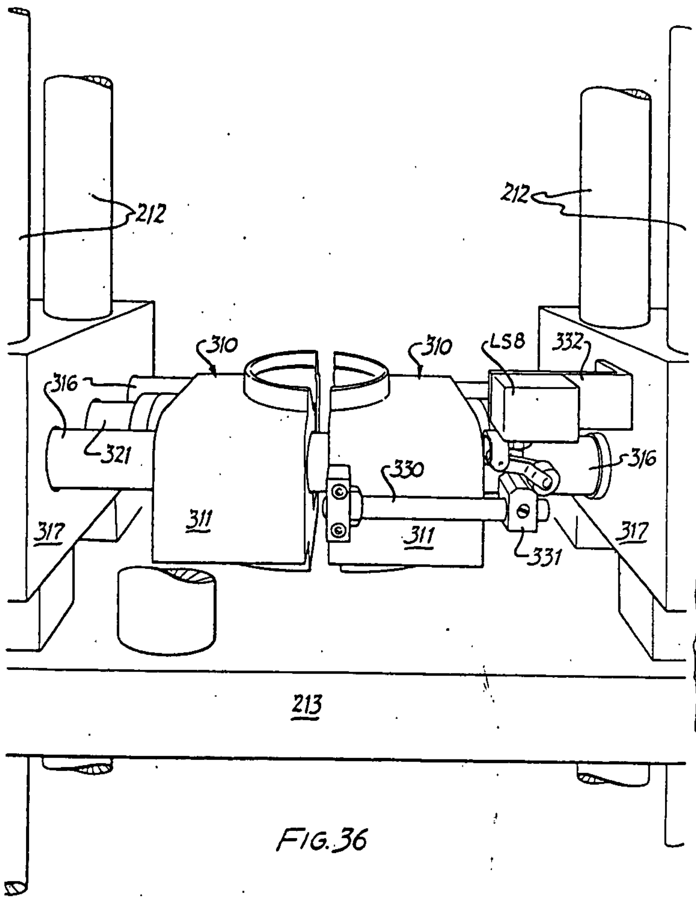
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FIG.36

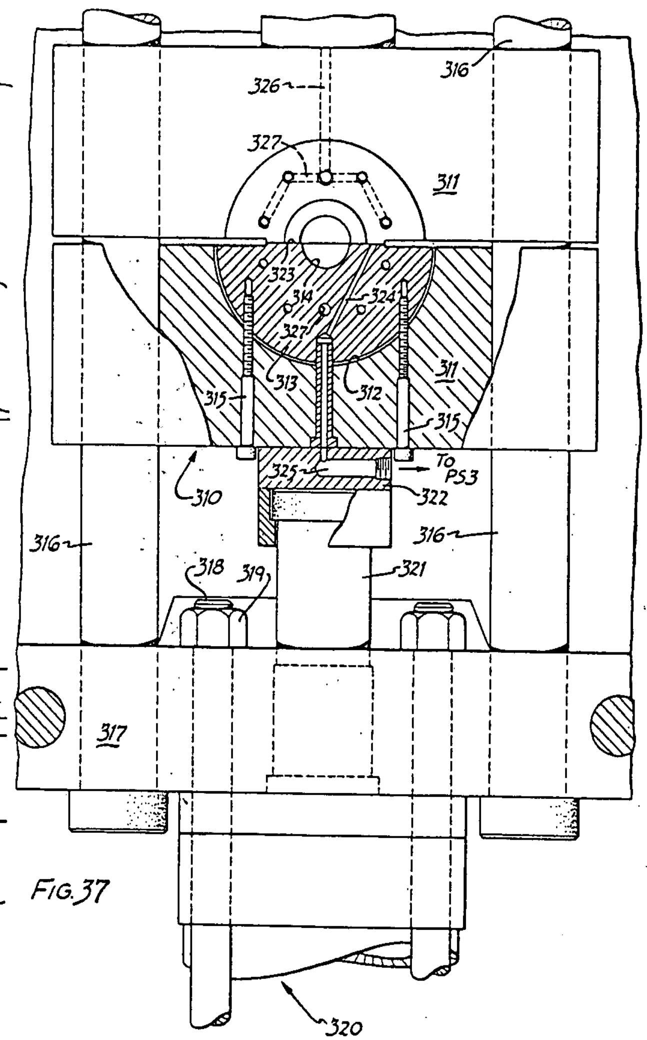
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FIG.37

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FIG. 38

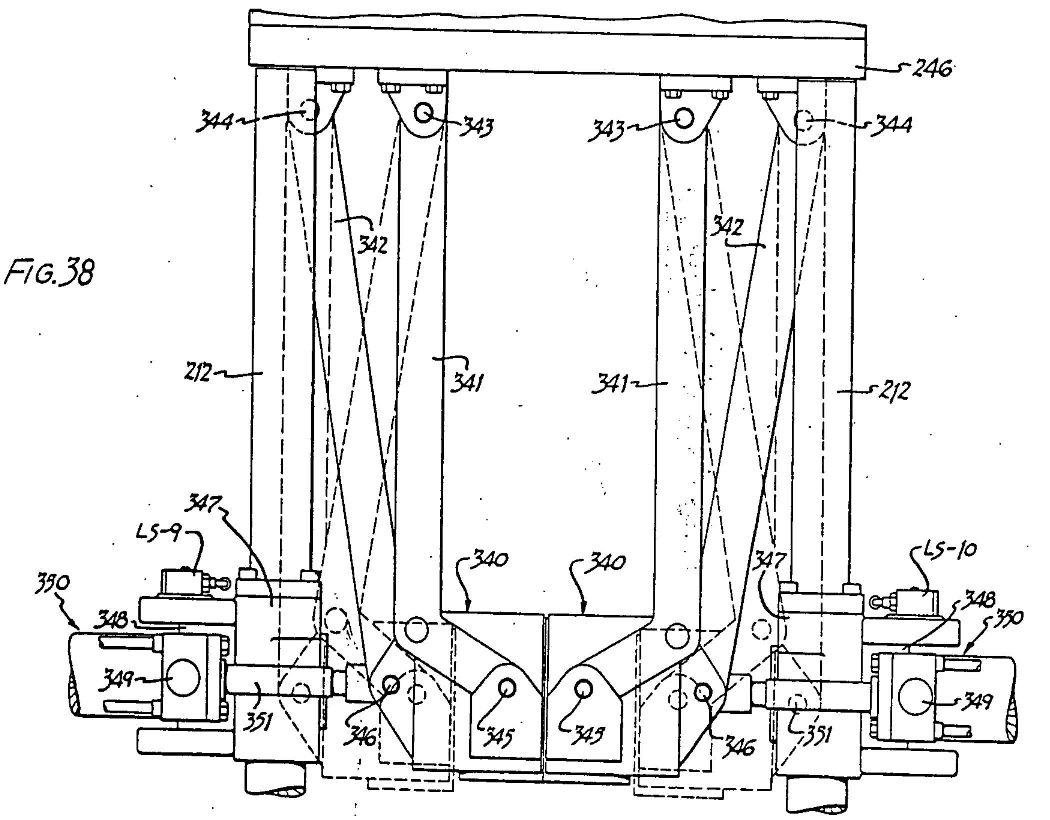
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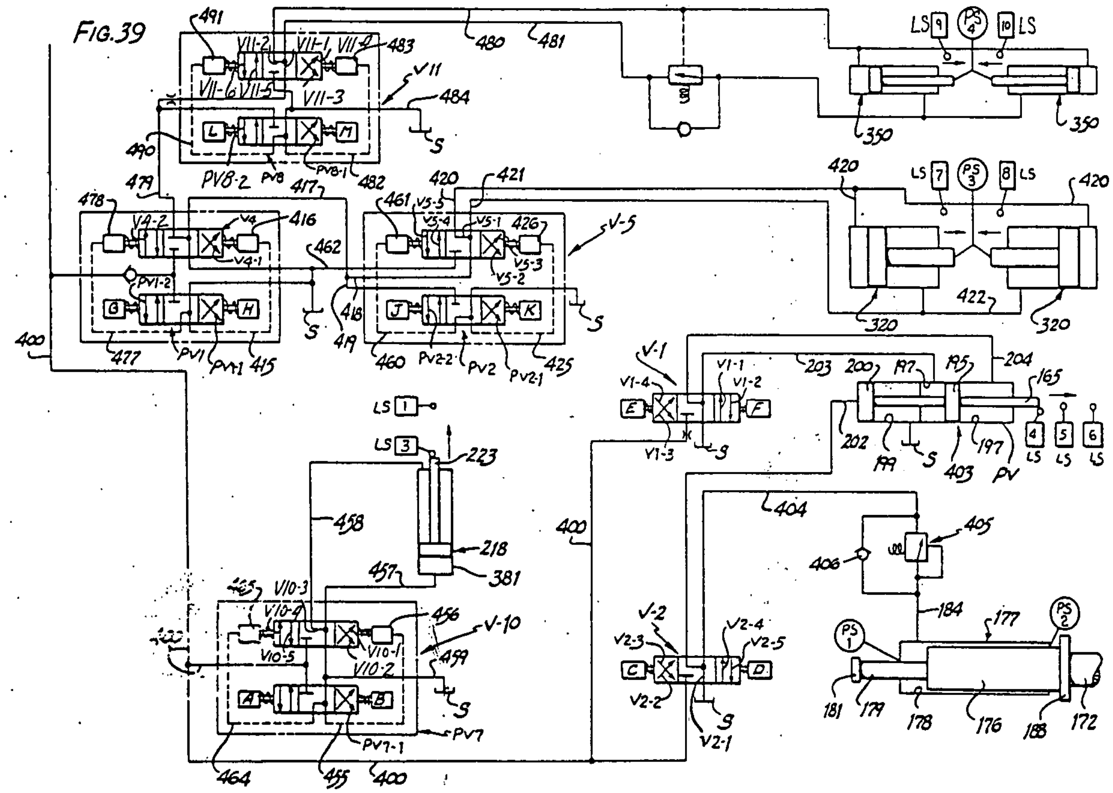
FIG.39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V4-1
V5-3
V5-2
PV1-2
G
H
J
K
S
S
418
422
400
477
PV1
PV1-1
415
419
460
PV2-2
PV2
PV2-1
425
320
320
V-1
V1-1
V1-2
203
200
197
195
204
165
V1-4
E
F
LS 1
V1-3
S
202
199
S
403
197
PV
4
5
6
LS
LS
LS
LS 3
223
458
400
404
405
218
406
457
381
465
V10-3
V10-4
456
V-10
V10-1
V10-5
459
V10-2
V-2
V2-4
V2-3
V2-5
184
177
PS 1
PS 2
C
D
A
B
S
V2-2
S
181
179
178
176
188
172
PV7-1
PV7
V2-1
464
455
400

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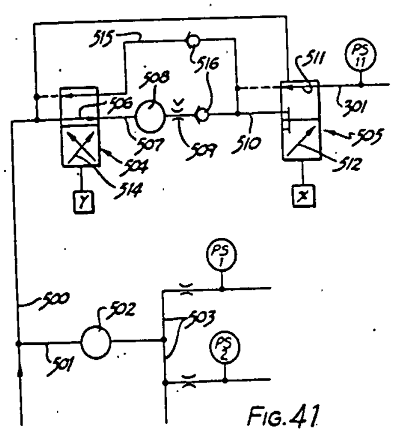
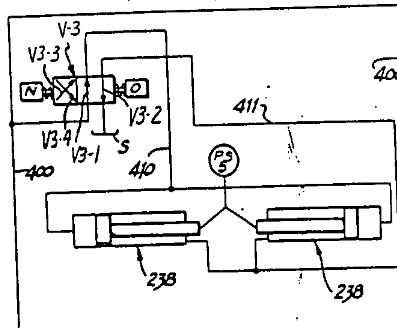


FIG. 41



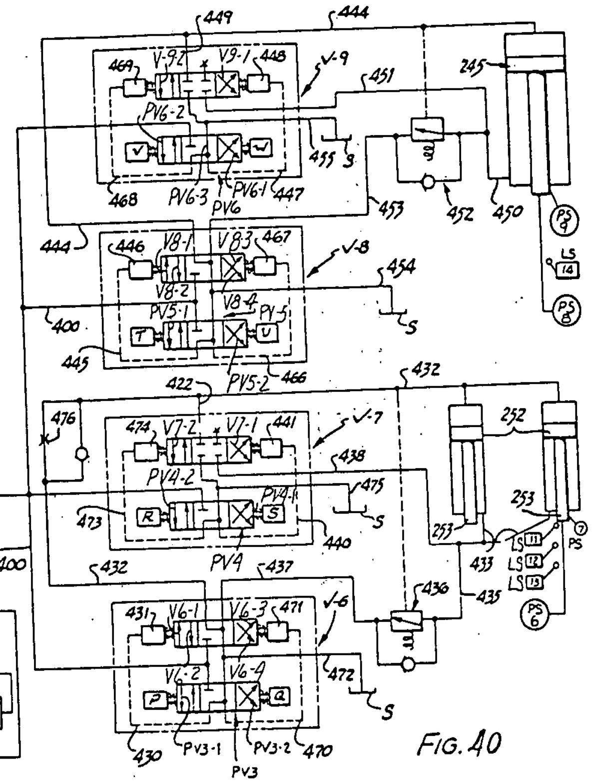


FIG. 40